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DISCOVER THE DEADLY DANGER THAT LURKS BELOW YELLOWSTONE

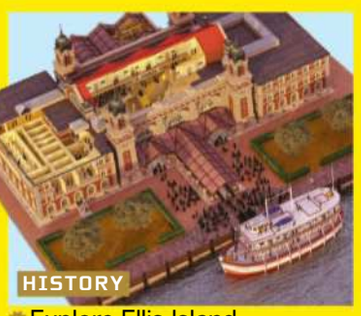
WORLD CUP 2018 TECH

TECHNOLOGY

The Seattle Space Needle

TRANSPORT

Nissan's hi-tech BladeGlider



HISTORY

Explore Ellis Island

PLUS

ROBOPETS: YOUR NEXT-GEN CYBER FRIENDS

MAKE MAGNETIC SLIME

INSTANTLY FREEZE WATER

FUTURE

ISSUE 113

SPACE

SPACE VS HOLLYWOOD

Sorting the science fact from the science fiction

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SCIENCE

THE SCIENCE OF YOUR EMOTIONS

The biology that shapes your mood revealed

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ISSUE 113

WELCOME

The magazine that feeds minds!

Seeing footage of the lava from Hawaii's Kilauea volcano swallowing a car really brings home how destructive these forces of nature can be... and how powerless we are to stop them. But these recent eruptions are nothing compared to the catastrophic supervolcanoes from our planet's past. A supervolcanic blast could level cities, coat entire continents in ash, even change the climate.

These tales of apocalyptic disasters are the stuff many sci-fi films are made of (case in point: 2005's *Supervolcano*). In the space section, we explore how realistic some of our sci-fi favourites really are.

Also this month, we meet the latest generation of robopets, discover the biology behind emotions, explore the history of US immigration and go city-hopping via rocket. Enjoy the issue!

Jackie **Jackie Snowden**
Editor

"Our emotions determine who we follow, who we trust, who we care about..."

Science of emotions, page 32

Meet the team...

Charlie G
Production Editor
When VAR first came into use I thought it may ruin the flow of football, but I'm coming round to the idea. Actually, I might review that thought...

Baljeet
Research Editor
As far as space films go, *The Martian* is one of the most scientifically accurate, but what about other favourite Hollywood blockbusters?

Charlie E
Staff Writer
Whether you're happy or sad, all of your emotions are driven by chemicals released by your body to help you survive. Find out more on page 32.

Scott
Staff Writer
Could we be witnessing the rise of the robopets, or is the idea of a robotic companion all bark and no bite? Find out more on page 52.

Duncan
Senior Art Editor
BOOM! Ever wondered what would happen if the Yellowstone supervolcano actually erupted? Well, hurry and turn to page 20 before it blows!

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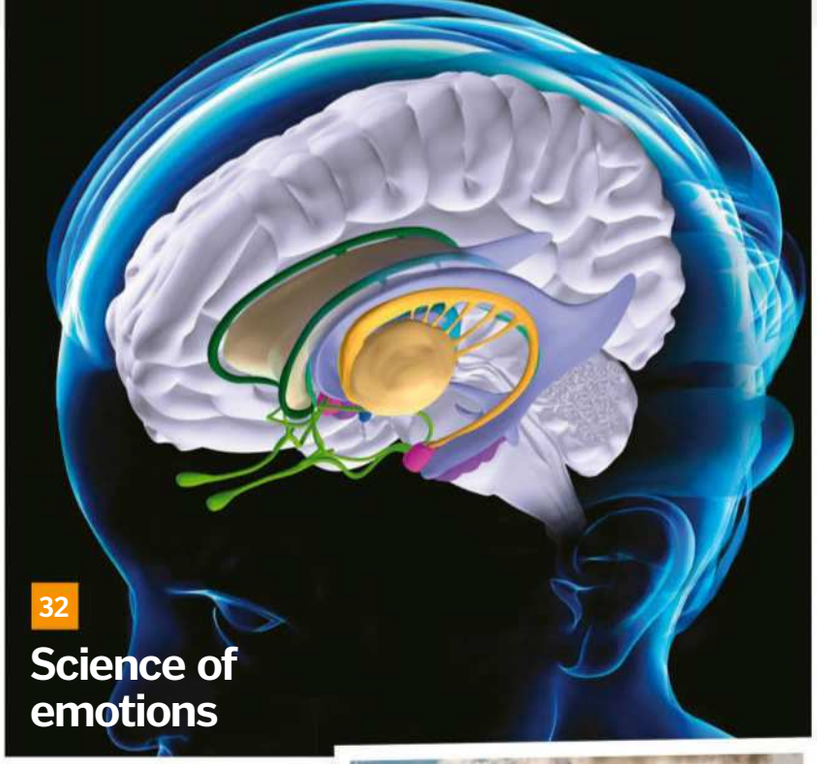
CONTENTS



32 **Science of emotions**

58 **Seattle's Space Needle**

29 **World's tallest waterfall**

42 **Rocket power**

MEET THIS ISSUE'S EXPERTS...

Jamie Frier
Multimedia journalist Jamie is a fan of all things sport, technology and tea-related. He has a fondness for discovering new titbits of trivia.

James Horton
Former **HIW** member James is a biochemist and biotechnologist. He is currently doing a PhD in machine learning and evolutionary theory.

Jo Stass
Jo has been a writer and editor for over six years. She is particularly interested in the natural world and technological innovations.

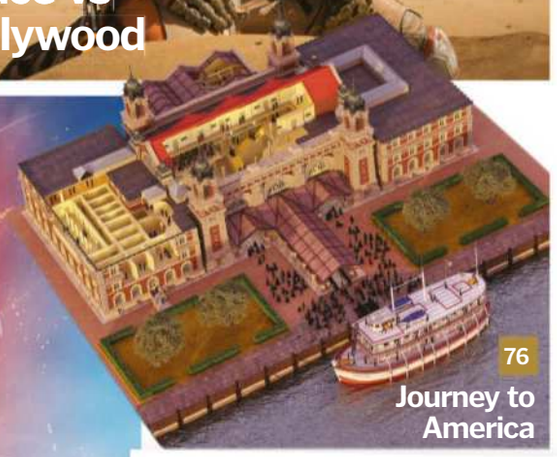
Jodie Tyley
The former editor of **HIW** and **All About History** has tackled many topics in her career, from science fiction to science fact and Henry VIII to honey badgers.

Jonathan O'Callaghan
With a background in astrophysics, former **HIW** and **All About Space** journalist Jonathan enjoys delving into the wonders of space.

Laura Mears
Biomedical scientist Laura escaped the lab to write about science, and is now working towards her PhD in computational evolution.

Lee Cavendish
Avid stargazer Lee writes for our sister magazine, **All About Space**, and has a degree in observational astronomy.

Stephen Ashby
Stephen has been a writer and editor for over seven years. He is endlessly intrigued by technology and Earth science.



REGULARS

Steve Wright
Steve has worked as an editor on many publications. He enjoys looking to the past, having also written for **All About History** and **History Of War**.

Tim Williamson
History Of War
Editor Tim has a passion for all things military, but studies and writes about a range of historical eras.

Tom Lean
Tom is a historian of science at the British Library working on oral history projects. His first book, *Electronic Dreams*, was published in 2016.

Victoria Williams
Evolutionary biologist and **World of Animals** writer Vicky is fascinated by the natural world and happiest when she's outdoors.

Galactic mega merger

This artist's impression depicts the impending collision of 14 galaxies, as recently spotted by ALMA. When the galaxies do eventually merge they will form a colossal cluster, becoming one of the most massive objects in the cosmos. This epic example of galactic evolution is set to take place approximately 12.4 billion lightyears away, near the edge of the observable universe.

Problematic pollen

This false-colour SEM image shows pollen grains of the flame lily at approximately 350x magnification. If you've been suffering from hay fever this spring, microscopic grains such as these are to blame. Pollen grains contain a plant's male reproductive cells, and these typically have surfaces that cling easily to passing insects, improving the chances of being carried to other plants for pollination.

SCIENCE

Researchers discover New Zealand's unique blue whales

A pod of blue whales that swim along the coast between the North and South Islands are different from other members of their species

A paper published in *Endangered Species Research* has reported that a pod of blue whales in New Zealand may be genetically different from other blue whale populations. The report follows the recent controversial decision by the New Zealand Government to issue its first permit for the mining of iron sands from the seafloor, which could potentially disrupt wildlife in the area.

Leigh Torres, a principal investigator at the Oregon State University's Marine Mammal Institute and co-author of the paper, hypothesised that blue whales might be residing in the South Taranaki Bight (STB), the area of ocean between the two main islands of New Zealand. Torres suspected that the whales might be setting up residence because of the ample food supply, but her hypothesis went against the traditional view that blue whales are a migratory species that don't remain local to one area.

Along with graduate student Dawn Barlow, Torres embarked on a mission to find out if the whales were migratory pods from, for example, Australia, or a distinct population of New Zealand whales. The teams used biopsy darts to analyse the genes of the pod members, compared photographs of whales from other regions, and listened to recordings from hydrophones deployed in the area.

"We never heard any Australian blue whale calls – just the local New Zealand population," explained Torres in a press release. "When we conducted biopsies of individual whales, we also discovered that they are genetically distinct from other blue whale populations."

The research resulted in the identification of 151 genetically distinct New Zealand blue whales between 2004 and 2017, but they estimate there are at least 718 in the area.

Blue whale song

Blue whales are an endangered species that are under threat from climate change and the destruction of their habitat. Researchers are keen to understand this species to help boost conservation efforts and keep these magnificent marine mammals protected.

One way in which we can learn more about blue whales is by using hydrophones to record their songs and calls to better understand their behaviour. Their songs are so powerful they can communicate with other whales that are 100 kilometres away.

Previous studies of their vocalisations have revealed that their calls change depending on the time of day and the season. Scientists also think that shorter calls are used to communicate with other members of the species nearby, while full whale songs are sung to call across greater distances.

"Her hypothesis went against the traditional view that blue whale are a migratory species"

Blue whales filter krill from the water using baleen plates in their mouths

SPACE

NASA to launch a helicopter on Mars

The agency plans to examine the Red Planet from above

There have been 54 missions to Mars, but only 23 have ever landed successfully and not failed after touchdown. Yet NASA haven't let this deter them in their efforts to understand and explore the mysterious planet. The agency's next Mars rover – Mars 2020 – will carry with it a small, autonomous helicopter on its belly pan ready to deploy on the surface.

NASA Administrator Jim Bridenstine has commented in a press release, "The idea of a helicopter flying the skies of another planet is thrilling. The Mars Helicopter holds much promise for our future science, discovery and exploration missions to Mars."

The development of the Mars helicopter started in August 2013 at NASA's Jet Propulsion Laboratory. The team have spent four years optimising the technology, designing, redesigning and testing the tiny robot that will one day grace the skies of the Red Planet. It weighs under 1.8 kilograms, but it will be sturdy enough to enter the thin atmosphere of our neighbouring planet. This makes it more difficult to achieve lift so the helicopter will have two counter-rotating blades. These blades will rotate at around 3,000 rotations per minute – some ten times the rate of a helicopter on Earth.

Once safely on the Red Planet, NASA will start a 30-day flight campaign of up to five flights, ranging from a 30-second vertical hover (three metres above the surface) to a 90-second flight over a few hundred metres, opening up a new era of Mars exploration.

The Mars helicopter will be the first attempt at flying an autonomous probe on another planet

ENVIRONMENT

NASA completes flights to survey the Arctic ice

Operation IceBridge, NASA's mission to monitor changes in polar ice, has finished mapping the western basin of the Arctic Ocean and Greenland's fastest-melting glaciers. The spring mapping survey started on 22 March and concluded on 2 May.

HISTORY

Jurassic fossil is the missing link in crocodile family tree

A fossil originally unearthed in northwest Hungary in 1996 has recently been examined by a team of palaeontologists and identified as a new species, *Magyarosuchus fitosi*. This ancient reptilian missing link shares morphological features that belonged to two separate families of prehistoric crocodile.

TRANSPORT

Brits legally allowed to remotely park cars

New UK laws will allow drivers to use remote control parking technology on UK roads. Updates to the *Highway Code* are to now include the use of driver-assist technology, such as smartphone parking assistance apps.

Transport minister Jesse Norman said, "We will continue to review our driving laws in order to ensure drivers can enjoy the potential of these new tools safely."

SCIENCE

An egg a day could keep the doctor away

A recent study highlights the health benefits of the humble egg

Between 2004 and 2008, Chinese researchers recruited more than half a million adults to participate in a study investigating how egg consumption affects people's health. They found that those who ate an egg each day on average had a lower risk of suffering from strokes or cardiovascular diseases when compared to the participants who never or rarely ate eggs.

These results contradict those of some previous investigations, which had proposed links between eating eggs and cardiovascular disease or stroke because of their cholesterol content. However, most previous studies had much smaller sample sizes, which can make it difficult to draw reliable conclusions.

With over 500,000 participants, this latest study into egg consumption is one of the largest ever conducted

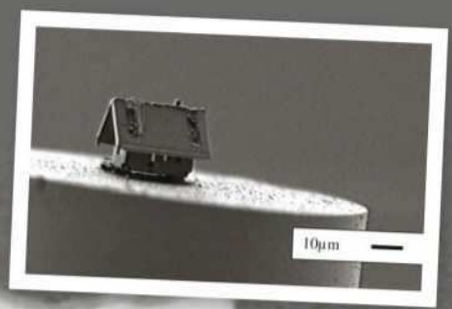
TECHNOLOGY

Robots assemble the world's smallest microhouse

Thinner than a human hair, this house showcases the potential of nanotech

A team of engineers from the Femto-ST Institute in France have assembled the world's smallest house using a new microrobotics system. Reported in the *Journal of Vacuum Science and Technology A* last month, the research team constructed the microscopic masterpiece on an optical fibre with the use of a focused ion beam, a gas injection system and a tiny manoeuvrable robot.

"We decided to build the microhouse on the fibre to show that we are able to realise these microsystem assemblies on top of an optical fibre with high accuracy," said Jean-Yves Rauch, an author on the paper.



This microhouse was created on a 300x300 micrometre area

SPACE

The Sun's adopted asteroid

Our Solar System has grown up with an asteroid we never knew came from another system, until now

A new study has revealed that an asteroid co-orbiting with Jupiter is the first to be identified as a permanent interstellar immigrant from another solar system. The asteroid, named (514107) 2015 BZ509, or BZ for short, stood out among its asteroid neighbours for its strange orbiting behaviour.

The majority of objects in our Solar System orbit the Sun in the same direction. BZ, however, defies convention and travels in the opposite direction in what's known as a retrograde orbit. Rather than just being a rocky rebel, this orbital defiance is an indication that BZ was born in a galaxy far, far away.

"If 2015 BZ509 were a native of our system it should have had the same original direction as all of the other planets and asteroids inherited from the cloud of gas and dust that formed them," said lead author Dr Fathi Namouni.

After the research team carried out simulations to trace the origins of the mysterious asteroid, they discovered that BZ has been in our Solar System for around 4.5 billion years. Though its origins are still unknown, BZ's discovery as the first permanent asteroid immigrant can offer clues into our own Sun's original star nursery and its environment.

Stellar nurseries, such as Westerlund 2 (pictured here), are thought to be places where asteroid exchange between solar systems could be possible

Interstellar traveller

BZ isn't the first asteroid to have ever visited our Solar System that we've spotted – it's just the first to stick around. The title of the first observed interstellar visitor belongs to 'Oumuamua, a cigar-shaped asteroid that was identified in 2017.

Using the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) at Haleakala Observatory in Hawaii, astronomers discovered this asteroid was not bound by the gravitational pull of our Sun. At its closest, 'Oumuamua passed 24 million kilometres away from Earth before heading to the outer Solar System. It is theorised that this asteroid came from a binary system, which is thought to eject other asteroids like 'Oumuamua.

The 400-metre-long asteroid was first spotted in October 2017

ENVIRONMENT

Could it be the end for Earth's largest amphibian?

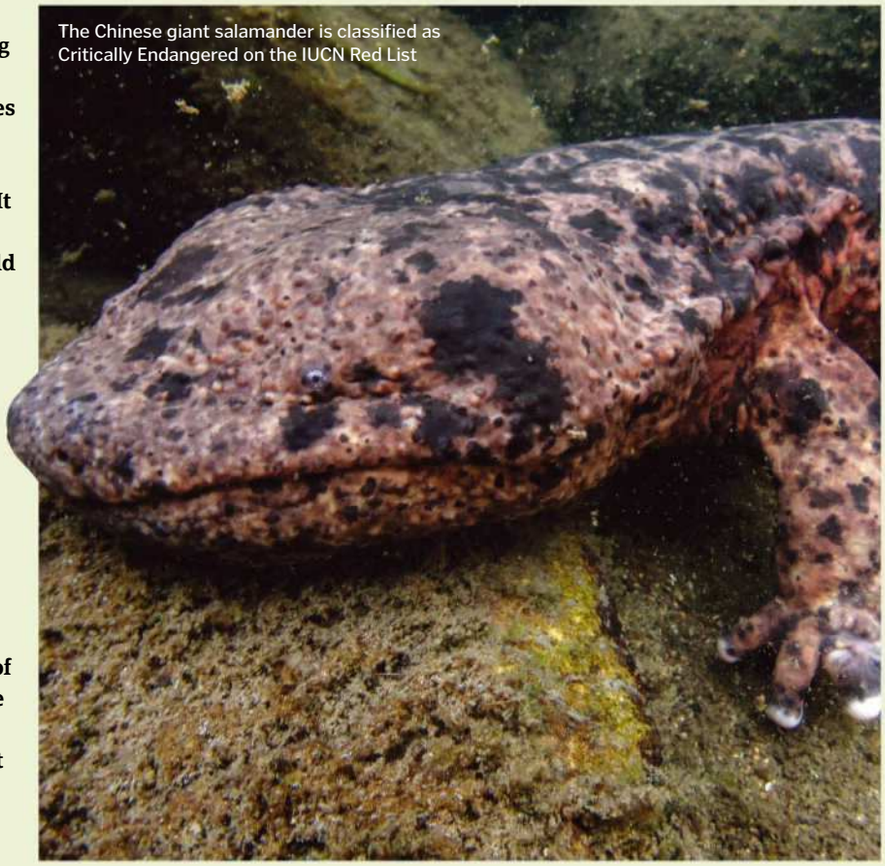
Traded as a luxury food item, Chinese giant salamanders are facing total extinction

Reaching up to 1.8 metres in length, the Chinese giant salamander definitely lives up to its name. Belonging to an ancient lineage of salamanders, these amphibious beasts come from a common ancestor that dates back to the Jurassic period, over 170 million years ago.

The giant amphibian does not feature gills, but rather exchanges oxygen from the water through its porous skin. It is this wrinkly skin that has been seen as a delicacy across Asia, and as a result human demand has decimated the wild population. A four-year-long survey was conducted by the international conservation charity Zoological Society of London (ZSL) across 97 sites in 16 of China's 23 provinces. They only found 24 of these salamanders across four sites over the four-year period – each one takes 16 weeks to find.

It is believed this decline is a direct result of wild exploitation for farming programmes. Though it is prohibited to harvest these wild salamanders, it is not illegal to release the farmed animal as a conservation method. In doing so, this can negatively affect the wild populations by inadvertently introducing and spreading pathogens, among other problems.

Report co-author Dr Samuel Turvey from ZSL's Institute of Zoology explains: "The overexploitation of these incredible animals for human consumption has had a catastrophic effect on their numbers in the wild over an amazingly short time span. Unless coordinated conservation measures are put in place as a matter of urgency, the future of the world's largest amphibian is in serious jeopardy."



The Chinese giant salamander is classified as Critically Endangered on the IUCN Red List

SCIENCE

Ebola vaccinations are being used to tackle the recent outbreak

Over 7,500 doses of the vaccine have been deployed to the Democratic Republic of the Congo

The Ebola vaccine rVSV-ZEBOV, which is yet to be officially licensed, will be used on high-risk populations in the Democratic Republic of the Congo (DRC). The experimental vaccine was found to be effective against Ebola when it was trialled in Guinea in 2015 during the West Africa outbreak, which is why the World Health Organization has recommended its use once again.

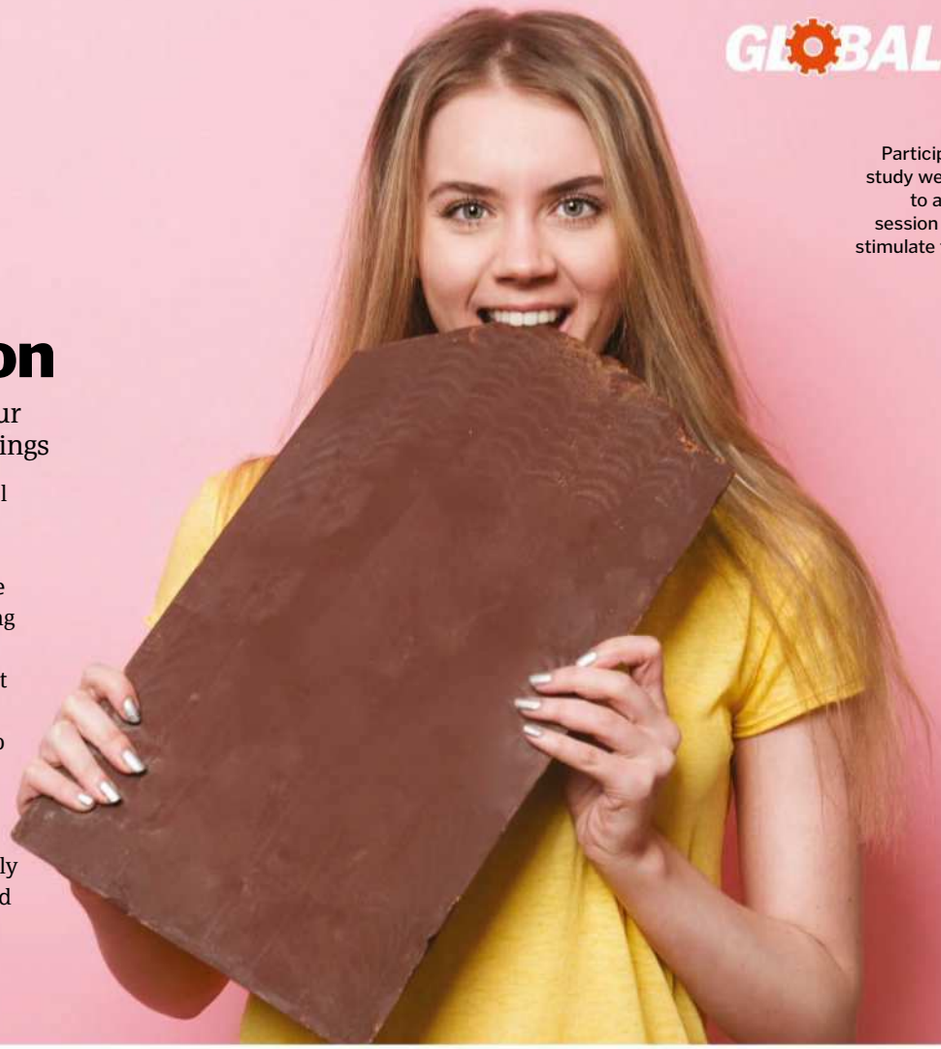
They will be implementing a ring vaccination strategy, which involves offering vaccines to all those who have been in contact with confirmed Ebola patients, as well as everyone who has been in contact with those contacts.

As of 21 May 2018, there have been 58 suspected, probable and confirmed cases of Ebola and 27 reported deaths in the Equateur Province of the DRC

SCIENCE

Curbing food cravings with brain stimulation

Research reveals that an alteration to our cerebral reward system could stop cravings



Participants in the study were exposed to a 30-minute session of dTMS to stimulate their brains

A procedure known as Deep Transcranial Magnetic Stimulation (dTMS) could provide a method for tackling obesity. The treatment uses magnetic fields to stimulate neurons in targeted areas of the brain, including those associated with our food reward system.

"For the first time, this study is able to suggest an explanation of how dTMS could alter food cravings in obese subjects," said Professor Livio Luzi, who worked on the study, which was presented at the European Society of Endocrinology annual meeting in Barcelona.

The study showed promising results after only one session, and the team hope moving forward they can use brain-imaging studies to identify the changes to the structure of the obese brain for future treatment.

ENVIRONMENT

Baby reef fish inherit tolerance to warming oceans

Researchers have found evidence that reef fish are inheriting genes that help them adjust to the warming of the oceans when their parents are exposed to increased water temperatures. The offspring selectively modify their epigenome to better tolerate the stressful conditions.

HISTORY

Modern-day sloths have a 'new' prehistoric ancestor

Researchers at McMaster University in Canada have extracted genetic information from a South American bone fragment belonging to a prehistoric sloth that is nearly 13,000 years old, linking it to the lineage of the modern-day two-fingered sloth. *Mylodon darwinii* was a giant ground sloth believed to have become extinct around 10,000 years ago. It has been named in honour of Charles Darwin.

SPACE

Neighbouring galaxy seen in a new light

The galaxy NGC 6744 is around 30 million lightyears away and is one of 50 local galaxies to be observed by the Hubble Space Telescope's Legacy ExtraGalactic UV Survey (LEGUS). From this data, a team of international astronomers have created the most comprehensive high-resolution ultraviolet-light image of the galaxy.

WISH LIST

The latest must-have technology

OK!Dolls

■ Price: **Each doll from £22 (approx. $30) / okdolls.com**

These aspirational dolls with inspirational careers are great fun for everyone and are both durable and stylish. They come in a variety of fun characters, including Emma the Engineer and Scarlett the Surgeon. We spoke to OK!Dolls founder Kim, who explained how one is crafted.

"I sketch and design each one by hand, and my husband Erik turns them into the vector illustrations. We then heat print them locally on a soft scuba fabric. Then it's back to us, where we cut, sew and fill them with an ecofill made from recycled plastic bottles, and then finish the dolls."

OK!Dolls seeks to open up the career possibilities we introduce to children by creating toys with real-world professions. The company's free global shipping means kids all over the world can play and dream big.

Ring video doorbell

■ Price: **Prices start from £89 / $99.99 / en-uk.ring.com**

Ring is designed not only to keep your property safe by monitoring your door; it's also extremely practical and means you'll never have to miss a parcel or a friend turning up unexpectedly when you're out of the house. You can monitor who is at your front door from wherever you are from your smartphone, tablet or computer. You'll also be the first to know if anyone comes into your front garden thanks to an instant alert motion detection system. The lowest budget of the range is great, suitable for both day and night and is compatible with iOS and Android phones.

Ultimate Lightning McQueen

■ Price: **£299.99 / $199.99 / sphero.com**

There is a wealth of remote control cars currently on the market, but few of them have a built-in personality like the Ultimate Lightning McQueen. Emulating the Disney-Pixar hero, this toy car brings McQueen to life with his animated eyes, animatronic mouth and characteristic speech.

Controlled through an accompanying joystick app, McQueen can perform pre-programmed tricks and turns such as drifts and doughnuts during his 40-minute battery life. Be careful not to crash him, as he'll let you know it hurts!

McQueen can reach speeds of almost ten kilometres per hour and only takes an hour to charge. The accompanying app is simple and fun to use, helping you learn new driving skills – McQueen even coaches you during a race. Fans of the Disney-Pixar movie *Cars* can also watch the film with McQueen by their side, and he'll react to the onscreen fun and comment throughout.

WIN an Ultimate Lightning McQueen

See page 95 for details

Ruggie

■ Price: **$69 (approx. £50) / ruggie.co**

It can be tempting to switch off your morning alarm and catch some extra shut-eye. Finding it hard to get out of bed is the reason so many of us oversleep, but Ruggie seeks to solve the problem by making you get up onto your feet rather than hitting snooze. It operates the same as any alarm clock but in the form of a small rug that you place next to your bed. When your alarm sounds, the only way of switching it off is to stand on it for three seconds. Once you're on your feet it's a lot less tempting to get back into bed.

Varidesk Pro Plus 36

■ Price: **£365 / $395 / Varidesk.com**

We spend a lot of the day bound to desks here at HIW HQ. With more research exposing the harmful effects of our increasingly sedentary lifestyles, we were excited to get our hands on the Varidesk. This clever device lets you transform any worktop into a standing desk in seconds. By squeezing the paddles on either side, the spring-assisted mechanism helps you raise the desk to your preferred height. Its two-tiered design helps your posture too; we found that having our screen raised and the keyboard at elbow height helped us to stop slouching so much.

The best feature of the Varidesk is that it's adaptable; you don't have to commit to being on your feet all day. With this system you have the flexibility to switch between standing and sitting whenever you feel like it. If you're looking to incorporate a standing workspace either at the office or at home, the Varidesk is a great choice.

EnChroma glasses

■ Price: **$349-$429 (approx. £260-£320) / enchroma.com**

Around 300 million people in the world have colour vision deficiency (CVD), but US company EnChroma have developed innovative glasses that can help restore some colour to their lives. These glasses use a colour-filtering lens to re-establish an accurate ratio of light reaching the eyes. This allows the wearer to view an enhanced vibrancy of colours and improve depth and detail perception.

EnChroma glasses are said to help 80 per cent of people with CVD, but they are not a cure for the condition and do not provide 100 per cent colour vision.

APPS & GAMES

Orbit

■ Developer: **HIGHKEY Games**

■ Price: **Free / Google Play / App Store**

Players have to battle against the forces of gravity to successfully propel coloured balls (planets) around varying amounts of different sized black holes to achieve the goal of each level. With each planet also having its own gravitational pull, *Orbit* is a fun and challenging game that can quickly become addictive.

The Road Bike Manual

■ Developer: **Haynes** ■ Price: **£2.99 / $2.99 / Google Play / App Store**

If you own a bike then this app is a must-have when it comes to repairs. As a 'how to' guide, *The Road Bike Manual* provides tutorials on how to fix different parts of your bike along with maintenance tricks and tips. Covering a whole host of categories and scenarios, this user-friendly interface provides easy-to-follow steps, saving you time otherwise lost to endless Googling for solutions.

EBird Checklist

■ Developer: **Cornell Lab of Ornithology**

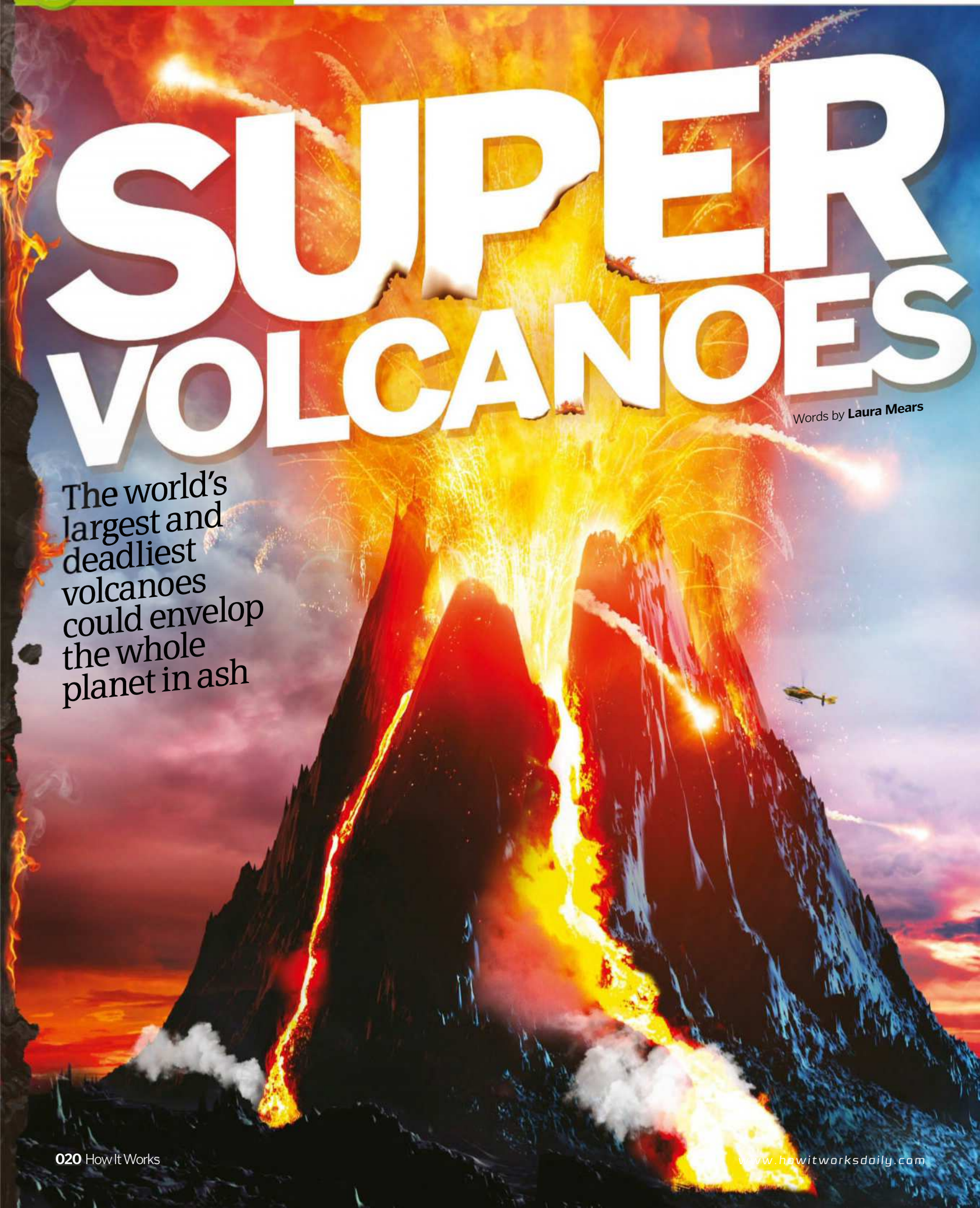
■ Price: **Free / Google Play / App Store**

With the recent beautiful weather in the UK, we're loving this app as we get out in the sunshine. Compatible with both Apple and Android, you can enter bird observations from any location in the world, and you even have map tools that mean you can see local birdwatching hotspots and add your own.

SUPER VOLCANOES

Words by **Laura Mears**

The world's largest and deadliest volcanoes could envelop the whole planet in ash



Supervolcanoes are some of the most destructive natural structures on the planet. Classified only after they have erupted, they eject more than 1,000 cubic kilometres of lava in one go. They're a thousand times more powerful than a standard volcano and so large that they could blanket the whole Earth in ash.

The ground collapses above them when they explode, and the scars that mark their positions consume so much of the landscape that they become virtually invisible. Yet bubbling pools of magma still seethe below the surface, venting hot steam and gas through the ever-weakening crust above.

Scientists grade volcanic eruptions on a scale of 0 to 8, known as the Volcanic Explosivity Index (VEI). The tiniest volcanoes at the bottom of the scale gently dribble magma, while the behemoths at the top spit out hundreds of tons at a time. There are only around 40 of these supervolcanoes worldwide, but just ten remain potentially active. They sit atop hotspots where magma leaks up from the Earth's mantle. Bubbles of molten rock accumulate under the ground, building pressure that stretches the Earth at its seams. Between major eruptions, pockets of heat leak out as spurts of lava, water and gas, but eventually the pressure becomes too much. The crust melts and cracks, heaving above the liquid rock below.

When supervolcanoes erupt in earnest the impact is catastrophic. Lava explodes upwards or bursts out in sheets, forming vast splatters and fast-moving lava plains. The temperature of the liquid rock can be as low as 300 degrees Celsius or as high as 1,160 degrees Celsius. It might advance slower than walking speed or vent at more than 60 kilometres per hour, and it tears through everything in its path.

Alongside the lava, supervolcanoes spew gas and ash. The heaviest particles settle within days, forming a blanket around the eruption that can be tens of centimetres thick. They smother crops and damage the eyes and lungs of animals.

Up in the sky, sulphur compounds react with the air, creating clouds that then unleash acid rain. Pollution races through the watercourse, impacting wildlife far from the source of the eruption. Tiny fragments of ash can remain airborne for months, scattering the sunlight and changing the climate across the globe.

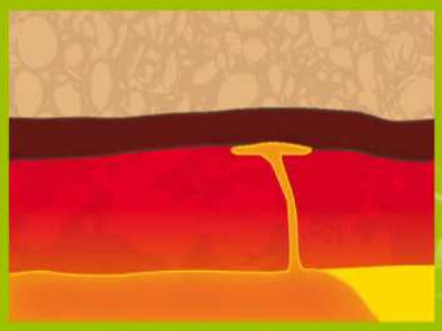
Luckily, supervolcano eruptions are rare; hundreds of

As of May 2018, over 1,700 residents on Hawaii's Big Island have been evacuated following the eruption of Mount Kilauea

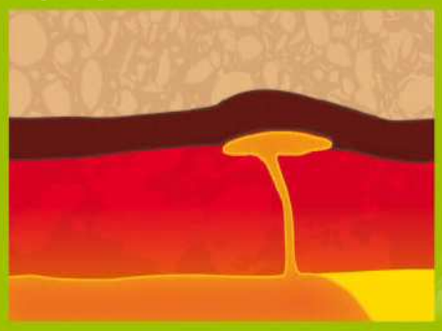
Kilauea is one of the most active volcanoes on Earth, but most of its eruptions are only VEI 0–1

Birth of a supervolcano

How a caldera forms, step-by-step

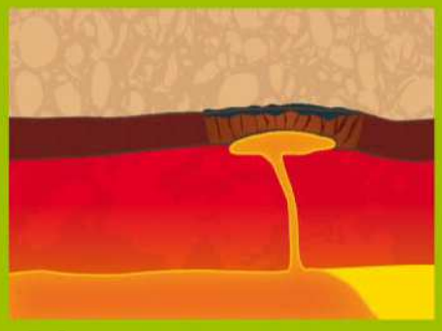


1 Hotspot
Intense heat in the Earth's mantle forces magma upwards.



2 Bulge
As magma gathers under the crust, a chamber starts to form.

3 Cracking
Stress weakens the ground above the chamber, forming cracks.



4 Collapse
The ground collapses, revealing the molten rock below.

thousands of years can go by between major events. As a result, predicting the next one is a major challenge. For this scientists use an arsenal of tools. The most basic are cameras, which are used to watch volcanoes in real time. Some are on the ground, others on satellites. They capture stills and video and scan the volcanoes in infrared to track their hotspots. Then there are seismometers, which detect motion in the ground. These usually measure in three directions: up and down, north and south, east and west.

There are more than 100 seismic recording stations worldwide, each one feeding data into a vast international network. Together they keep tabs on quakes and tremors that rip through the Earth when rocks and magma move. Seismometers not only reveal the origin, depth and magnitude of earthquakes; they also work as a 3D volcano scanner. Vibrations travel through different materials at different speeds, a bit like X-rays through the human body. Seismic waves move more slowly through hot, molten rock than cold, hard rock. Watching how tremors shift across the Earth can reveal the outline of underground magma chambers.

Very low frequency (VLF) induction can supplement this data. It's the same technology used in metal detectors, and it produces maps of the ground using electromagnetism. A transmitter coil sends a pulsing magnetic field into the ground, which interacts with anything conductive under the surface. The conductive material makes weak magnetic fields in return, sending signals back to a receiver coil. The changing signal across the ground reveals the shape of magma lakes and flows below.

When an eruption is imminent, the volcano will start to bulge. Scientists can track this using GPS and electronic distance measuring (EDM). GPS satellites ping radio waves from all angles to create millimetre-accurate maps of volcano outlines, while EDM uses infrared light to map the flanks of the volcano from the ground. Tilt-meters, or electronic spirit levels, can add real-time feedback around the volcano rim.

Active volcanoes also start to vent more gas as they approach an eruption, and this is detectable with a correlation spectrometer (COSPEC). These devices look at the light coming through plumes of volcanic gas and compare it to the light moving through normal air. This reveals how much gas is coming out of a volcano.

To really understand the potential of active supervolcanoes we also need to trace their history. Fortunately, the impact of past eruptions is still visible in ancient rock. When supervolcanoes explode they spit hundreds of cubic kilometres of material into the air, and this leaves its trace on the ground. Geologists look for vast calderas and spurts of lava hardened into spokes or plains. Their position reveals their age, and analysis of their chemical composition tells us much about their history.

Supervolcanoes are so colossal that signs of their eruptions appear across the world. Ice at the poles has trapped particles from ancient eruptions, and cores drilled from the Arctic and Antarctic are a valuable source of volcano history. Scientists crush the ice inch by inch in sterile lab conditions, collecting trapped sediments and bubbles of air. These then pass through spectrometers, chromatographs and microscopes to identify the particles and reveal the culprit.

Data like this from past eruptions can help scientists to map 'at-risk' areas. Though we can't yet prevent supervolcano eruptions, understanding the lava, ash, gas, mud and flooding that they can produce will help us to prepare for the future.

"Tiny fragments of ash can remain airborne for months"

Know your volcanoes

Different types of volcano erupt in dramatically different ways

Plinian
Violent jets shoot into the atmosphere, triggering vast lightning storms.

Icelandic
Fissures open up in the ground, leaking horizontally to form flat lava plains.

Dome
Slow-moving lava piles up at the mouth of the volcano.

Pelean
Flows ooze down the sides of the volcano, destroying everything in their path.

Volcanic winter

The fallout from a supervolcano eruption reaches far from the source

Eruption
The magma chamber bursts upwards. Hot ash, expanding gas and molten lava spill into the air.

Sulphur clouds
Sulphur reaches high into the atmosphere, forming dense acidic clouds.

Sun block
Small particles of ash and gas travel through the stratosphere, reflecting the sunlight.

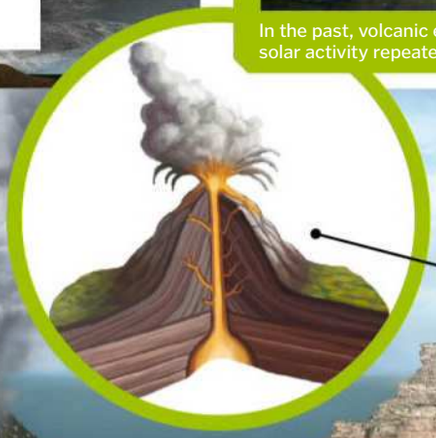
Volcanic chill
Temperatures drop for months, or even years, after the blast.

Acid rain
Sulphuric acid tumbles out of the air, polluting the water supply and damaging trees.

The 'Little Ice Age'

In 1257, Samalas erupted in Lombok, Indonesia, releasing millions of tons of sulphur dioxide and chlorine into the atmosphere, cooling the planet for half a century. Over 40km³ of magma spewed from the Earth, rising up over 40km into the air. Ash and gas rose into the stratosphere, above the clouds and spread out across the world. The particles reflected the sunlight, scattering it back out into space, and with the daylight blocked, Earth cooled. Data from tree rings and ice cores revealed that some of the coldest summers on record occurred in 1258 and 1259. As the centuries passed, the Sun's activity naturally dipped, and more volcanoes spit their ash into the sky. Between the 16th and 19th centuries, the climate changed so much that scientists call the period the 'Little Ice Age'.

In the past, volcanic eruptions and changes in solar activity repeatedly froze the River Thames



Strombolian
Expanding gas pushes blobs of lava into the air, emitting bright light.

Surtseyan
Like a Strombolian volcano but underwater, creating explosive bursts of expanding steam.

Vulcanian
Small, dark ash clouds explode from the crater and spill into the sky.

Cinder cone
Fragments of lava solidify around a central hole, forming a smooth cone shape.

Hawaiian
Fire fountains splatter lava and molten rock flows slowly across the ground.

Subglacial
Explosions melt the ice, spitting debris out onto the surface.

Submarine
Lobes of lava cool quickly underwater, forming distinctive pillows.

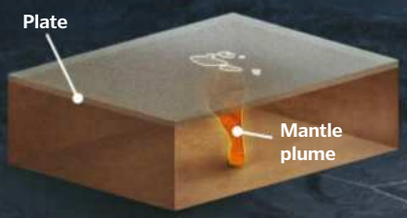
What lies beneath

Under Yellowstone's picturesque park, monstrous magma chambers lurk...

Hot water bubbles up as violent geysers in Yellowstone National Park

Tectonic activity

The North American tectonic plate moves around 2.5cm to the southwest each year, while the base of the plume stays put.

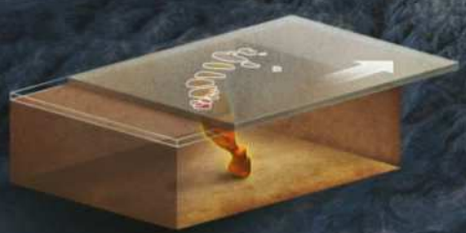


16 million years ago

Rising heat from the mantle plume melted the crust above it, generating the hotspot's first eruption.

12–7 million years ago

Further eruptions created more calderas, which drifted as the plate moved southwest. Ancient calderas from this hotspot can now be found in Nevada and Oregon.



2.1 million years ago

The Huckleberry Ridge eruption spewed out an estimated 2,500km^3 of rock, lava and ash – the largest known eruption in the hotspot's history.

Yellowstone calderas

Several overlapping calderas mark the sites of Yellowstone's previous eruptions; the most recent formed around 640,000 years ago.

Picabo caldera
10.3 million years ago

Big Bend Ridge caldera
2.1 million years ago

Yellowstone caldera
640,000 years ago

YELLOWSTONE NATIONAL PARK

Geothermal activity

Heat from the magma reservoirs powers the park's 10,000+ hydrothermal features, including geysers and hot springs.

Upper crustal magma reservoir
760°C

Lower crustal magma reservoir
980°C

Magma reservoirs

Two large pockets of magma lie below Yellowstone. They obtain their heat from the massive mantle plume below.

Mantle plume
1200°C

"Currently, there is nothing we can do to stop a supervolcano"

Is Yellowstone about to blow?

The world's most infamous volcano sleeps fitfully under a national park in Wyoming and Montana. Yellowstone has burst through the Earth three times in the past 2.1 million years, leaving vast scars on the landscape. The most recent eruption (640,000 years ago) left a 2,400-square-kilometre hole in the ground. Since then there have been at least 80 smaller eruptions, and the volcano remains active to this day.

Each year more than 1,000 earthquakes shake the park, and the surrounding ground still boils and hisses, venting gas and water into the air. Analysis of the area suggests that large eruptions happen every 600,000–800,000 years. With the last major outburst sitting squarely within that bracket, there has been much speculation about when the next one will occur. According to the US Geological Survey, a Yellowstone eruption would blanket everything within a 320-kilometre radius knee-deep in ash.

Monitoring stations are listening for signs of an impending explosion. Daily tremors should increase, becoming stronger and closer together. The ground will start to shift, creaking, cracking and bulging under the stress. Currently, there is nothing we can do to stop a supervolcano eruption, but NASA has an intriguing idea. Yellowstone vents increase their heat and pressure level by spitting water up to the surface, so drilling down into the volcano and pumping more water into the rock might help to cool it down. As a bonus, the steam could drive a geothermal power plant.

It's still just an idea, but at the moment there's no great rush. According to the National Park Service, an eruption in the next 1,000–10,000 years is very unlikely.

Yellowstone's hot springs are fuelled by the magma chambers below

Bruneau-Jarbidge caldera
12.5 million years ago

Twin Falls caldera
10–8.6 million years ago

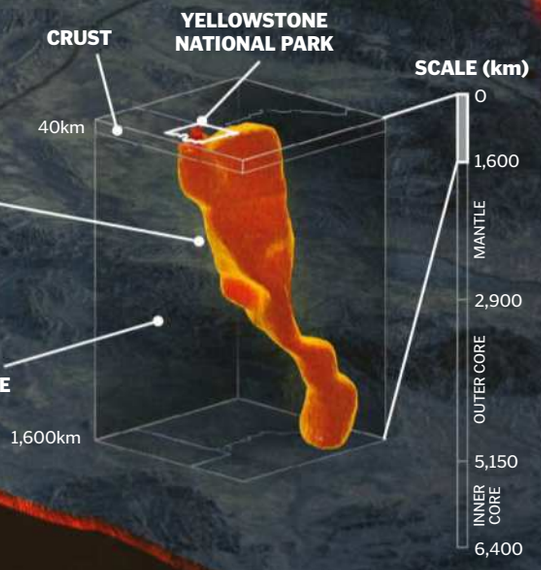
Heise caldera
6–4.3 million years ago

Trail of evidence

As the tectonic plate drifted, new areas of the crust were positioned over the hotspot. Evidence of past eruptions can be tracked along the Snake River Plain, which stretches from Wyoming through Idaho to Oregon and Nevada.

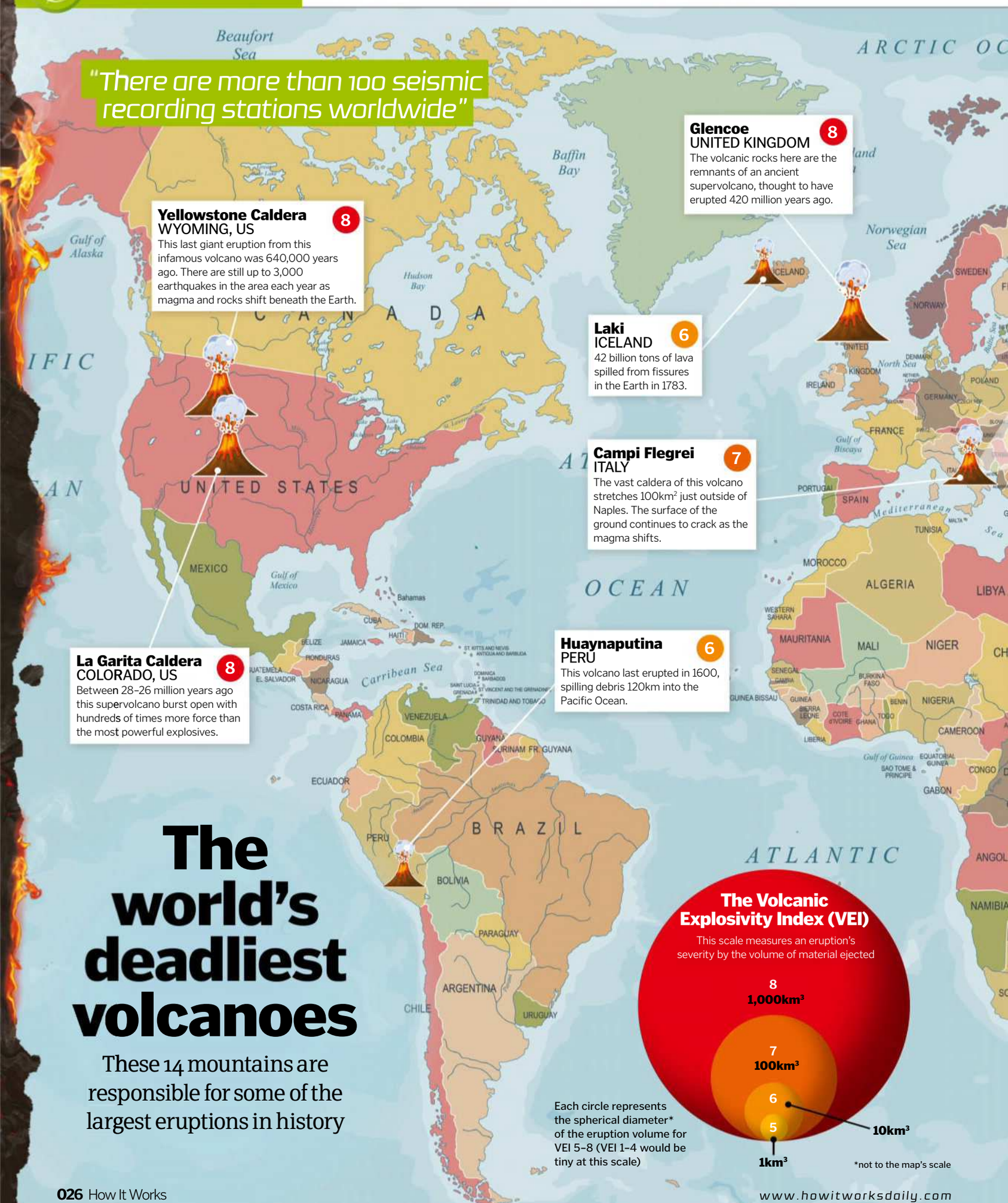
Mega-plume

The magma plume below Yellowstone may extend as far as 2,900km deep, down to the boundary between Earth's mantle and the outer core.



Mantle monster

The region's hotspot is the result of a huge mantle plume. Both the plume and the reservoirs above it consist of superheated molten rock.



"There are more than 100 seismic recording stations worldwide"

Yellowstone Caldera 8
WYOMING, US
This last giant eruption from this infamous volcano was 640,000 years ago. There are still up to 3,000 earthquakes in the area each year as magma and rocks shift beneath the Earth.

Glencoe 8
UNITED KINGDOM
The volcanic rocks here are the remnants of an ancient supervolcano, thought to have erupted 420 million years ago.

Laki 6
ICELAND
42 billion tons of lava spilled from fissures in the Earth in 1783.

Campi Flegrei 7
ITALY
The vast caldera of this volcano stretches 100km² just outside of Naples. The surface of the ground continues to crack as the magma shifts.

La Garita Caldera 8
COLORADO, US
Between 28–26 million years ago this supervolcano burst open with hundreds of times more force than the most powerful explosives.

Huaynaputina 6
PERU
This volcano last erupted in 1600, spilling debris 120km into the Pacific Ocean.

The world's deadliest volcanoes

These 14 mountains are responsible for some of the largest eruptions in history

Each circle represents the spherical diameter* of the eruption volume for VEI 5–8 (VEI 1–4 would be tiny at this scale)

*not to the map's scale

Vesuvius 5
ITALY
This infamous volcano buried the town of Pompeii when it erupted in 79 CE.

Etna 5
ITALY
The most active volcano in Europe often spits lava into the air.

Thera 7
GREECE
This island volcano may have buried a city (perhaps inspiring the myth of Atlantis) when it erupted in 1620 BCE.

Toba 8
INDONESIA
Four monumental eruptions formed Lake Toba. The island at its centre is a mountain of solid magma, pushed up through the caldera by the pressure beneath.

Pinatubo 6
PHILIPPINES
Scientists predicted the 1991 eruption of this volcano, saving over 5,000 lives.

Tambora 7
INDONESIA
In 1815, this super-colossal volcano entered the record books with the largest eruption ever recorded. It spewed so much ash into the air that there was no summer the following year.

Krakatoa 6
INDONESIA
This colossal volcano erupted in 1883, creating waves that killed more than 36,000 people.

Taupo 8
NEW ZEALAND
The most recent supervolcano eruption came from this lakebed in New Zealand 1,800 years ago. The magma chamber sits around 7km under the water.

The heart of a supervolcano contains a bubbling magma chamber

Meet the world's largest rodent

With dog-sized bodies, guinea-pig-like faces and feet like a duck's, capybaras are undeniably unique

It's not hard to see why capybaras were originally thought to be a sort of fuzzy pig – standing up to 60 centimetres tall and with a block-like head and no tail, they're not immediately recognisable as rodents. These strange-looking animals live in South America, always near water. Capybaras need rivers and lakes to keep their dry skin healthy and to provide them with food in the form of water plants. Webbed feet help them to move through the water and – just like hippos – their ears, eyes and nostrils are all at the top of their head, so they can submerge almost all of their body if a predator approaches.

Capybaras are known for their gentle and sociable natures. A typical group has about ten members, but they've been observed hanging out in groups of up to 100 in the dry season. They're most active at dawn and dusk but will wait until darkness falls to sneak into the water for a meal if they don't feel safe. Like other rodents, capybaras have teeth that grow constantly to cope with all the chewing – because they're so big, they can chomp their way through 3.6 kilograms of vegetation in a day.

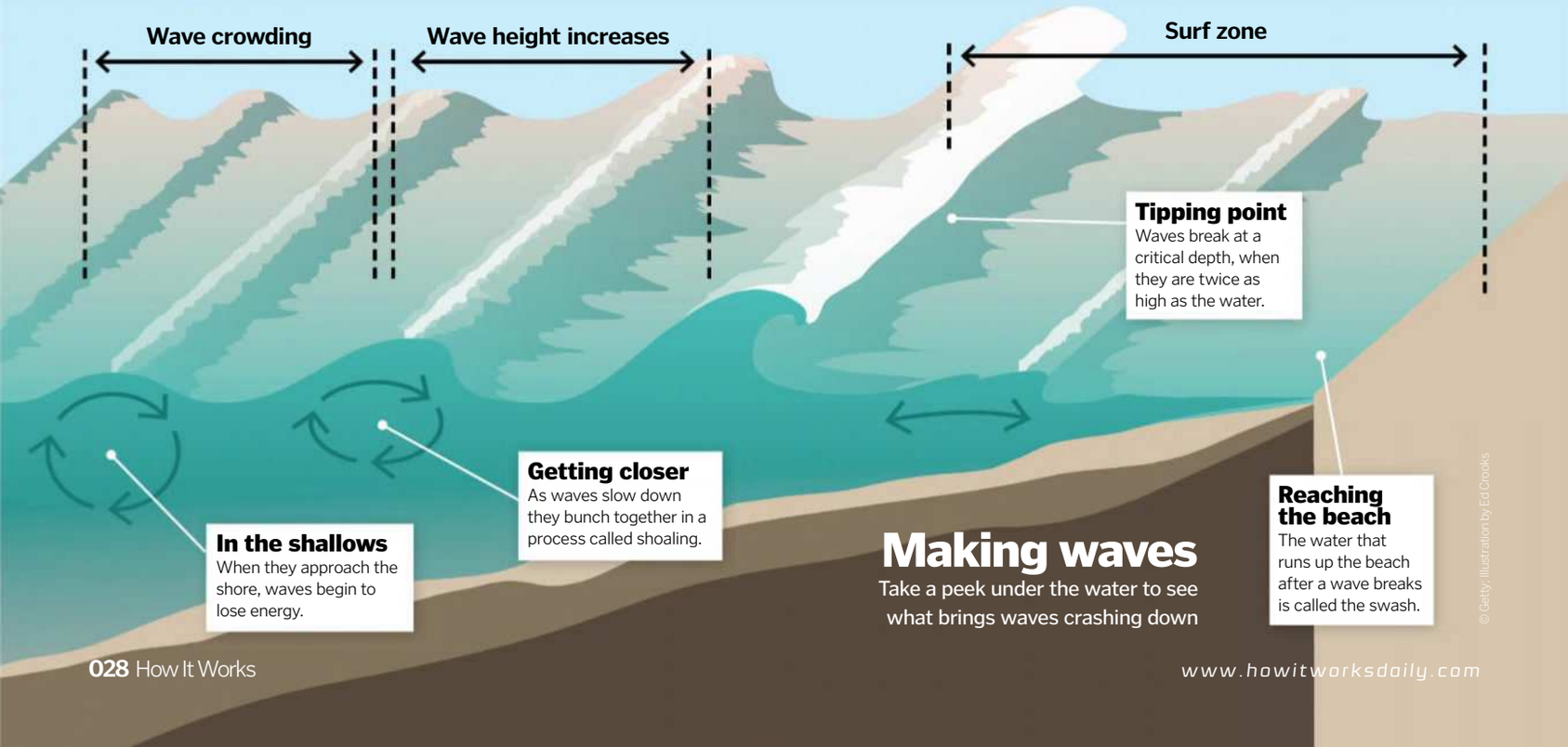
Capybaras are placid creatures, happy to let birds rest on them and eat insects from their fur

Young capybaras learn quickly from their mothers, following them on land and in the water

What makes a wave break?

Find out what happens when the ocean meets the shore

Waves are formed when the wind blows over the surface of the sea. Energy from the wind sets particles in the water rotating around each other, creating a wave that can roll for several kilometres. When the wave reaches the shore and the water becomes shallower, friction from the seabed begins to slow it down. It loses energy from the bottom first, causing it to bunch up on itself and get taller until the back of the wave overtakes the rest and breaks into whitewash. On gently sloping shores the wave simply spills over, but steep slopes create dramatic crashing waves.



Making waves

Take a peek under the water to see what brings waves crashing down

The world's largest waterfall

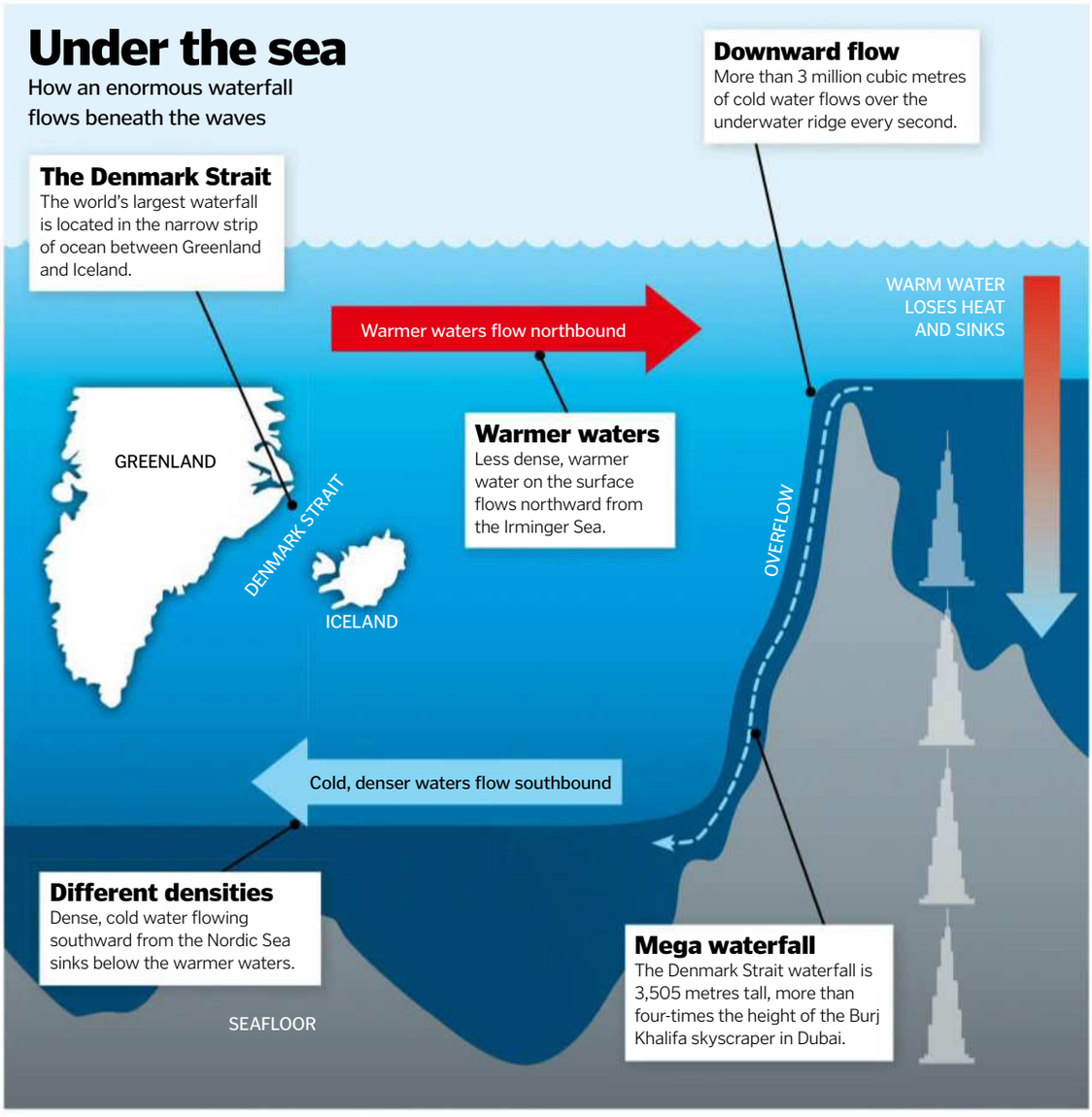
Discover why you might struggle to visit the tallest waterfall on Earth

With their staggering power and awe-inspiring beauty, waterfalls are one of the most popular natural wonders to visit on Earth. However, if you were hoping to see the world's tallest waterfall, then you'd better pack your diving gear.

While most people think of Venezuela's Angel Falls as the largest waterfall in the world, that title actually goes to a ridge beneath the Denmark Strait. Here, starting 600 metres below the water's surface, is a waterfall that plunges 3,505 metres to the seafloor.

This underwater cascade is made possible due to differing water densities. In the strip of sea between Greenland and Iceland, cold waters from the north meet warmer waters from the south. The molecules in cold water are less active and more tightly packed together than those in warm water, making them much denser. Therefore, when the two meet, the cold water sinks below the warm water, where it flows over an enormous ridge to create an undersea waterfall.

As well as being incredibly tall, the Denmark Strait waterfall is also very wide, stretching 160 kilometres across. It really would be an incredible sight to behold on land, but unfortunately, as it is already surrounded by water, the falls are completely undetectable without scientific equipment. So maybe hold off on packing your bags just yet!



5 WHOPPING WATERFALLS

1 Angel Falls – Venezuela
The tallest waterfall on land is 979m tall, three-times shorter than the Denmark Strait falls.

2 Inga Falls – DR Congo
25,768m³ of water flows over the world's largest waterfall by volume every second – equating to over 2.2bn m³ a day!

3 Khone Falls – Laos
The widest land waterfall in the world measures an incredible 10,783m across.

4 Niagara Falls – Canada-US
The world's most-visited waterfall attracts around 28 million people each year.

5 Boyoma Falls – DR Congo
The fastest waterfall has a mean annual flow rate of 17,000m³ of water per second.

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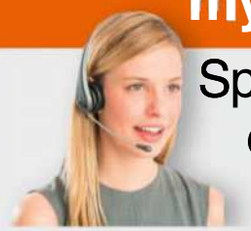

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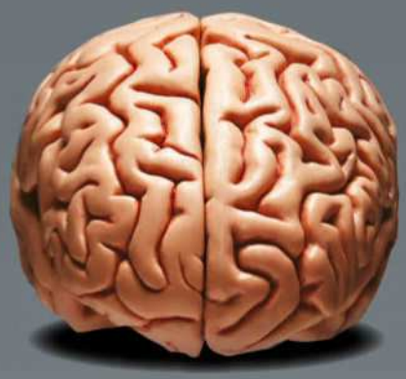
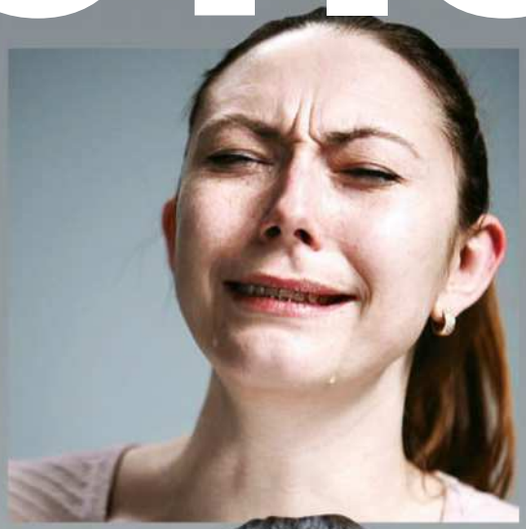
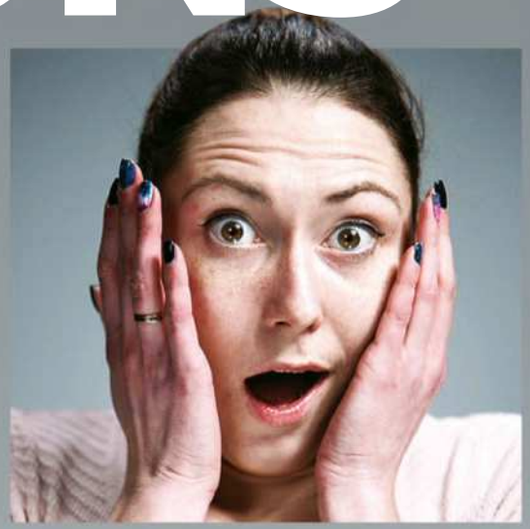


THE SCIENCE OF EMOTIONS

How our ancient brains evolved the perfect way to keep us safe by controlling the chemicals in our minds to moderate our behaviour

Words by **Charlie Evans**





How are you feeling right now? Are you relaxed laying on your sofa and listening to the gentle sounds of the dawn chorus outside your window? Or maybe you are tense with your shoulders hunched up around yourself as you try to get five minutes peace in a busy office? You would think that it is easy to work out if we are happy or sad, angry or calm, but humans cycle through such a vast array of emotions throughout their lives it can be difficult to distinguish them from one another.

Emotions are not a simple experience. Every time you feel something your body initiates a physiological change, a chemical release and a behavioural response. This process involves multiple processes working together, including your major organs,

neurotransmitters and limbic system. Your limbic system is the most primordial part of your brain, thought to have first evolved in early mammals. It's filled with ancient neural pathways that activate our emotions in response to stimuli and controls our fight-or-flight response through the autonomic nervous system.

This response evolved from a need to make decisions based on our emotions. As our body fills with adrenaline and our heart starts racing we prepare to react. Do we stay to fight the bear that has come scavenging for food, or do we flee to somewhere safe? We can still feel the effects of this response. When we are confronted for not doing the dishes we might feel the same fight-or-flight response as our adrenaline starts to flood our system. Our heart rate and breathing increases, the fine hairs on our arms might stand on end, and our hands feel clammy as we decide if we are going to stay and argue or if we are going to escape to to safety of our bedroom.

The biological sensations in our bodies in response to emotions can feel very similar to one another. Imagine your palms sweating, feeling your cheeks warm as they flush red, and your heart pounding in your chest. You could feel this because you are sitting nervously in the dentist's waiting room, or you could be excited as you wait to see your loved ones after they return from a holiday – the physiological reaction is the same. The interpretation of emotions is our logical brain rationalising these responses and describing them as feelings. We take into consideration the context and label our emotions accordingly. However, we don't all do this the same way. Because our bodies cause different floods of chemicals in response to different environmental triggers, each person naturally reacts to situations differently.

Have you ever seen someone who is being berated in a meeting but facing the onslaught with nothing more than a slightly raised eyebrow? Or watched as someone finds out some bad news but keeps their composure? You are sure that you would have raised your voice or burst into tears, but our responses are defined by how our neurons are

"We feel our emotions, and not just in our head and heart – our bodily state changes to react to the chemical storm in our system"

The chemistry of emotions

Where two neurons meet, a very small gap (synapse) exists between them. The electrical impulse travelling along the axon of the neuron must convert into a chemical signal to bridge this gap. The chemicals that do this are called neurotransmitters. These so-called chemical messengers are involved in our different responses to situations.

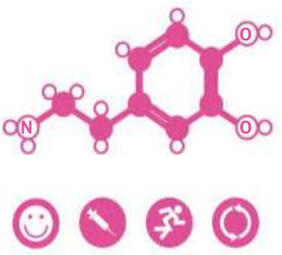
Your emotions depend on fluctuating levels of neurotransmitters, which cause the activation of different parts of the brain responsible for different moods, or activate parts of the brain that trigger the stimulation of the autonomic nervous system.

Adrenaline

Released by the adrenal glands that sit on top of each kidney, adrenaline increases the flow of blood to our muscles, raises our heart rate and dilates our pupils. It is crucial in our fight-or-flight survival response.

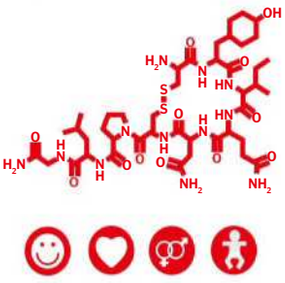
Noradrenaline

Similar to adrenaline, the release of this chemical can result in increased levels of alertness, helping to prime us for action if needed. It also increases our blood pressure and widens our air passages.



Dopamine

This is the addictive reward chemical that your brain craves. It serves to motivate you to seek out the things you need for your survival. We can sometimes find ourselves enslaved by this ancient reward mechanism.



Oxytocin

Also known as the 'cuddle hormone', oxytocin is released when you're close to another person. It's essential for making strong social bonds, and it's also a key part of why we want to trust people.

GABA

Responsible for regulating muscle tone, gamma-Aminobutyric acid (GABA) also regulates the communication between brain cells. It can calm us down by reducing the rate at which our neurons fire.

Acetylcholine

This is the main neurotransmitter in the parasympathetic nervous system that slows our heart rate, contracts smooth muscles, dilates blood vessels and increases bodily secretions.

Glutamate

The most abundant neurotransmitter in the vertebrate nervous system, glutamate is used by nerve cells to transmit signals to other cells. Too much of it can cause cognitive impairments.

Endorphins

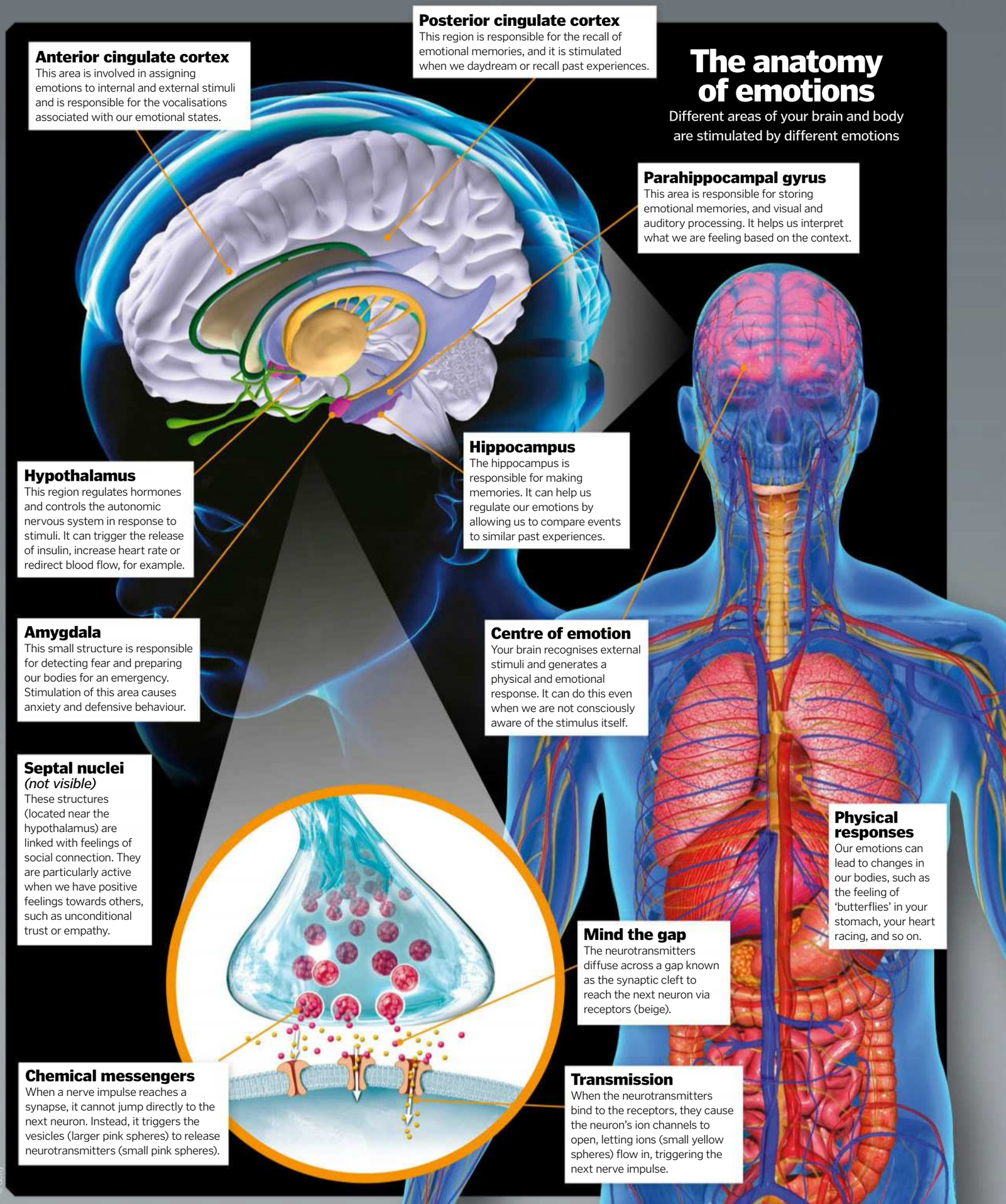
Triggered by the sensation of pain, endorphins work to inhibit the transmission of pain signals. Capable of producing a sense of euphoria, studies have suggested endorphins may also be stimulated by laughter.

Serotonin

Serotonin is linked to our wellbeing and happiness, and our levels of it are affected by exercise and exposure to sunlight. It also helps to regulate our mood balance, sleep cycle and digestion.

The anatomy of emotions

Different areas of your brain and body are stimulated by different emotions



Posterior cingulate cortex
This region is responsible for the recall of emotional memories, and it is stimulated when we daydream or recall past experiences.

Anterior cingulate cortex
This area is involved in assigning emotions to internal and external stimuli and is responsible for the vocalisations associated with our emotional states.

Parahippocampal gyrus
This area is responsible for storing emotional memories, and visual and auditory processing. It helps us interpret what we are feeling based on the context.

Hippocampus
The hippocampus is responsible for making memories. It can help us regulate our emotions by allowing us to compare events to similar past experiences.

Hypothalamus
This region regulates hormones and controls the autonomic nervous system in response to stimuli. It can trigger the release of insulin, increase heart rate or redirect blood flow, for example.

Amygdala
This small structure is responsible for detecting fear and preparing our bodies for an emergency. Stimulation of this area causes anxiety and defensive behaviour.

Centre of emotion
Your brain recognises external stimuli and generates a physical and emotional response. It can do this even when we are not consciously aware of the stimulus itself.

Septal nuclei
(not visible)
These structures (located near the hypothalamus) are linked with feelings of social connection. They are particularly active when we have positive feelings towards others, such as unconditional trust or empathy.

Physical responses
Our emotions can lead to changes in our bodies, such as the feeling of 'butterflies' in your stomach, your heart racing, and so on.

Mind the gap
The neurotransmitters diffuse across a gap known as the synaptic cleft to reach the next neuron via receptors (beige).

Chemical messengers
When a nerve impulse reaches a synapse, it cannot jump directly to the next neuron. Instead, it triggers the vesicles (larger pink spheres) to release neurotransmitters (small pink spheres).

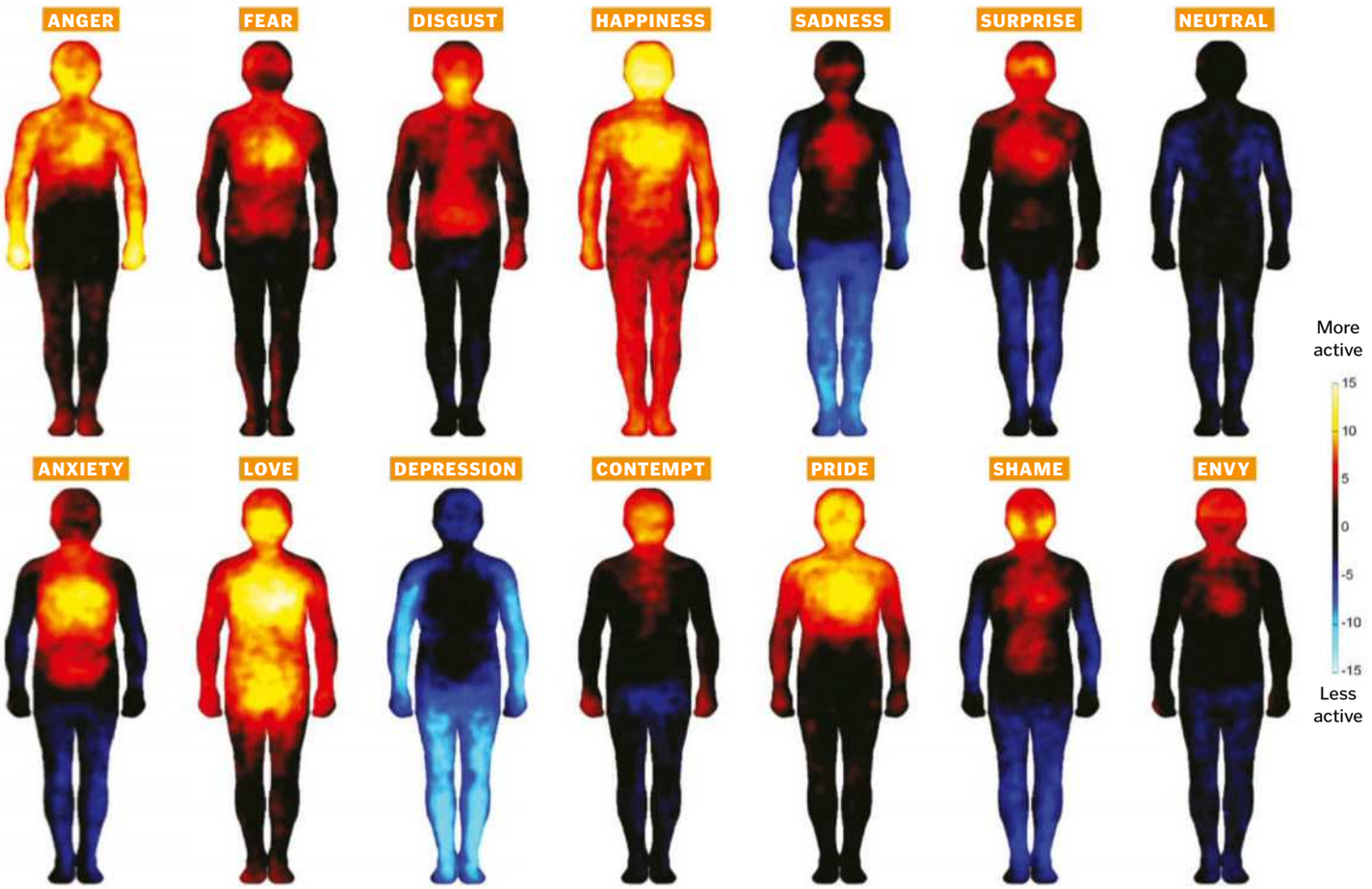
Transmission
When the neurotransmitters bind to the receptors, they cause the neuron's ion channels to open, letting ions (small yellow spheres) flow in, triggering the next nerve impulse.

The chemicals released when we're close to our family help us to build trust and closeness

networked together. Our past experiences and genetic predispositions influence our brain chemistry and therefore our physiological responses, which in turn determine how we react to various situations – like someone cancelling on us last minute, or having a friend surprise us by showing up at the front door unannounced.

At times our emotions can seem like an irrational response, but our brains have carefully evolved these mechanisms with just one target – keeping us alive. While we interpret different emotions as positive or negative, the most ancient parts of the human brain developed them on the principle that we must survive. We evolved emotions as a means of communicative function and to help us navigate social interactions and our environment safely: they are designed to protect us. Our fear responses were originally a survival tactic that warned us of potential dangers, such as our innate unease around spiders and snakes. Then there is the feeling of disgust, which warns us of foods or other substances that may be dangerous.

Our other emotions are responses to social interactions that keep us part of a group. We are fundamentally a social species, and throughout our evolution have relied on our tribe to help us survive by working together to find food and shelter. Anger is a response to perceived social threats or a signal of dominance, pride can help us to boost our social status, while shame is intended to decrease our standing within a group. These emotions maintain the social balance of our



Emotions as sensations

We feel our emotions, and not just in our head and heart – our bodily state changes to react to the chemical storm in our system. We might feel a tight knot in our stomach as we dread walking onto a stage to give a speech, or we might feel our cheeks flush red when we answer a question wrong.

Researchers from Aalto University in Finland explored how humans physically feel their emotions by mapping the sensations topographically. Their findings were consistent across Western European and East Asian cultures, which suggests the way people feel during an emotional experience stems from a biological source rather than a cultural interpretation. The study also highlighted that emotions adjust our bodily state to either prepare ourselves physically to fight or flee or to encourage us to seek out enjoyable social reactions.

The study included over 700 participants from Finland, Sweden and Taiwan, and researchers induced different emotional states before asking them to colour bodily areas on images of the human body to describe in which areas they felt activity increasing or decreasing.

tribe – who we follow, who we trust, who we care about.

The fundamental emotions that motivate us individually are almost always sadness and happiness. Sadness results from loss and serves the biological purpose of motivating a person to recover that loss, whether it is a young child searching for their mother in a supermarket, or trying hard to get a new job after being dismissed. But the ultimate human emotion is happiness, and we are all in search of it.

When you're sitting around a campfire, safe in the countryside with some close friends and good food, you feel happiness because you have found the resources that your primitive brain is seeking. Our species is drawn so much to happiness because this emotion is our brain's reward system for finding environments where we are free from threat. A healthy human brain copes with sadness when social bonds are broken, communicates with our loved ones and can recognise and regulate our emotions even when they do not feel particularly positive.

The next time you sit in an airport departure lounge, look for the emotions. Our bodies have created these experiences – the tears as we say goodbye, the smiles and laughter as we are reunited – for the purpose of keeping us alive. Our emotions and feelings are fundamentally what make us human, but it means we're in for a bit of a rollercoaster along the way.

The emotional mechanisms in our bodies evolved to keep us safe and connect us with others

"Reading the emotions of others is a vital skill for navigating our way through life"

Universal expressions

Reading the emotions of others is a vital skill for navigating our way through life – it would be awkward to misunderstand your friend as happy when they're actually angry with you.

There has been a long-established view that the way we express our feelings using our facial expressions is universal and crosses all cultures for seven basic emotions: anger, disgust, fear, joy, sadness, surprise and contempt. For over a century, studies have explored the theory of universal expression by asking people to interpret photographs displaying various emotions, although there are some cultures around the world that do not have the same perception of certain emotions.

One study found that people living in the Trobriand Islands off Papua New Guinea didn't interpret images of people who were wide-eyed with their lips parted as they gasped as a sign of fear. Instead, the Trobrianders interpreted this emotion as anger. This research is some of the first to suggest that how we express our emotions is not universal, and may differ between societies.

While the expression of happiness and sadness is generally the same all over the world, surprise and fear can be interpreted differently between cultures

How many emotions do we have?

It has long been thought that there are only six different emotions: anger, disgust, fear, happiness, sadness and surprise. It has been hypothesised that any other emotions are just a combination of these basic feelings, such as anticipation being caused by a mixture of fear and happiness. However, a recent study published in *Proceedings of the National Academy of Sciences of the United States of America* from researchers at UC Berkeley suggests that we may have many more emotions that are distinctively different to one another, but still related.

The study used 2,185 short videos with the intent to evoke emotions in the 853 participants. Clips included a cute baby playing with some fluffy puppies, a man holding a tarantula inside his mouth, and a happy couple getting married. Participants were asked to record how the videos made them feel and how strongly it evoked a response. The study suggests that there are 27 distinct emotions, including awe, awkwardness, calmness, confusion, disgust, nostalgia, sadness, sympathy, horror and triumph.

We may have more emotions than we are able to express in our languages

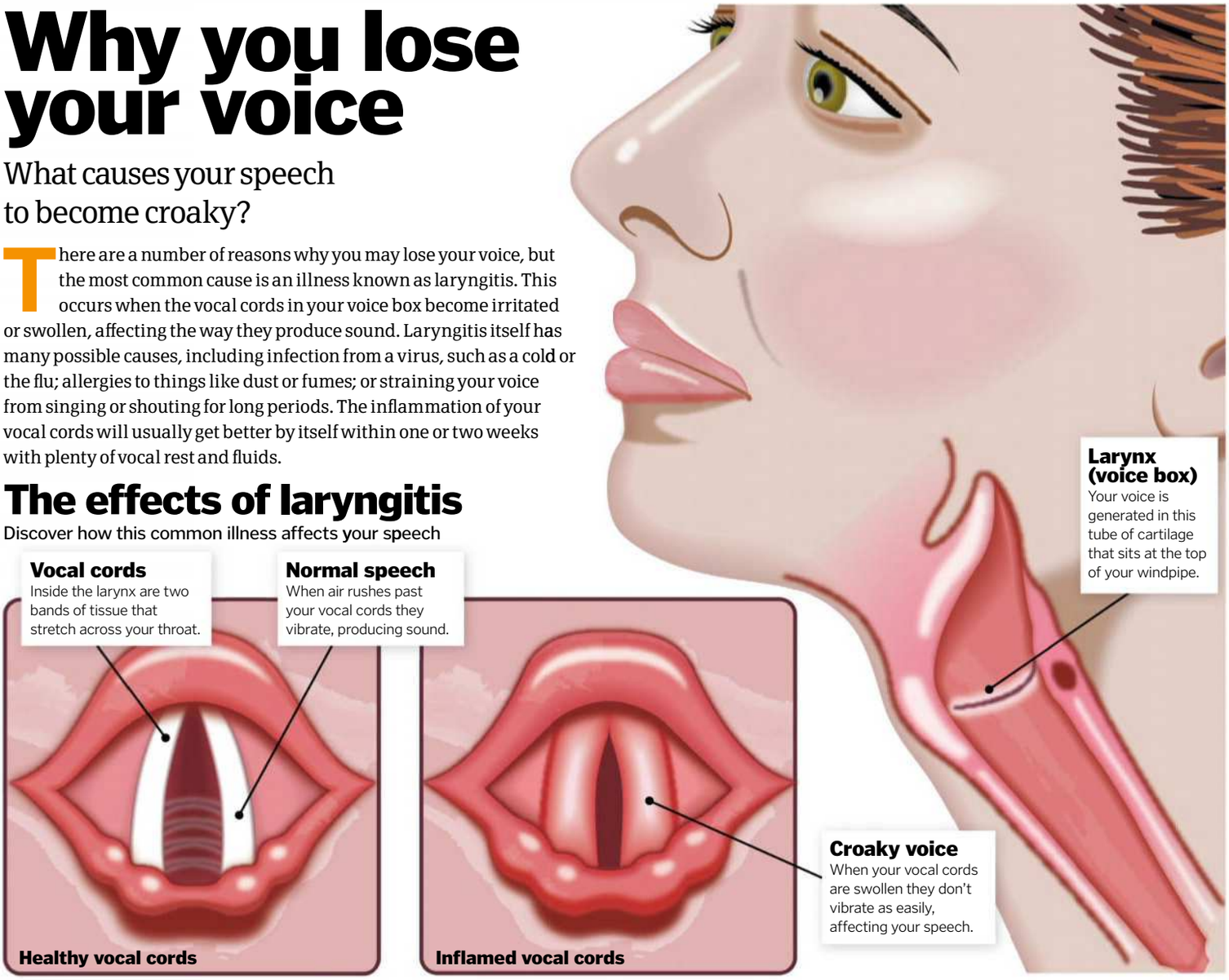
Why you lose your voice

What causes your speech to become croaky?

There are a number of reasons why you may lose your voice, but the most common cause is an illness known as laryngitis. This occurs when the vocal cords in your voice box become irritated or swollen, affecting the way they produce sound. Laryngitis itself has many possible causes, including infection from a virus, such as a cold or the flu; allergies to things like dust or fumes; or straining your voice from singing or shouting for long periods. The inflammation of your vocal cords will usually get better by itself within one or two weeks with plenty of vocal rest and fluids.

The effects of laryngitis

Discover how this common illness affects your speech



What is dry ice?

The secret to creating a spooky fog with CO_2

Popular in scary movies and big-budget stage productions, dry ice is a very different substance to the cubes of frozen water that keep your drink cold. Instead of H_2O, dry ice is actually the solid form of CO_2, or carbon dioxide, the gas we breathe out and plants use to photosynthesise. CO_2 freezes into a solid at -78 degrees Celsius (much lower than the temperature at which water freezes) and when it reaches room temperature it turns directly from a solid into a gas rather than a liquid. Not only is this useful for creating an atmospheric fog; it is also great for keeping things refrigerated on long journeys. By packing food in dry ice, it can be kept cool in transit without there being a messy puddle of water when it reaches its final destination.

Creating dry ice is a little more difficult than just freezing water. First you have to cool and pressurise CO_2 gas to turn it into a liquid, then depressurise it so it expands back into a gas. This causes a rapid temperature drop that freezes the gas into solid dry ice.

Dry ice changes from a solid to a gas in a process called sublimation

The higher the percentage of DHA in the lotion, the darker your tan will be

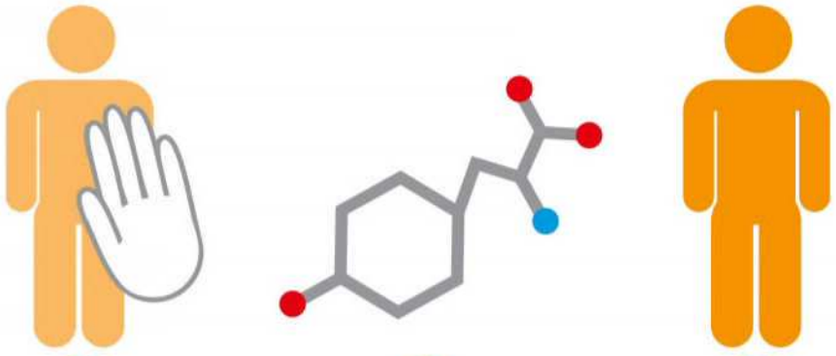
How does fake tan work?

The clever chemistry behind the lotions that give you a sun-kissed look

If you're looking for a golden tan but don't have the time – or weather – to bask in the Sun's rays, then you might prefer to fake it instead. Tanning lotions contain the chemical dihydroxyacetone (DHA), which creates a browning reaction when applied to the skin – the same reaction that causes bacon to change colour when it's cooked. The effect is gradual, taking around two to four hours to work, and it only lasts for up to ten days because it fades as your dead skin cells shed. Some fake tans may also contain erythrulose, another chemical with a more gradual browning effect, and sunblock to protect against the Sun's UV rays.

A tan in a bottle

What happens when you apply fake tan to your skin?



1

Application

Dihydroxyacetone in the lotion reacts with amino acids in the top layer of your skin.

2

Chemical reaction

Chemicals called melanoidins are produced through a Maillard reaction, the same type of reaction responsible for browning cooked meat.

3

Golden tan

The structure of the melanoidins means they absorb certain wavelengths of light, making your skin appear tanned.

What are smelling salts?

Discover how a quick sniff can revive you from unconsciousness

Although smelling salts were more commonly used in Victorian times to bring people round after they had fainted, they are still sometimes used today by athletes looking to boost their alertness. Traditionally they are made from a mixture of strong-smelling ammonium carbonate crystals and perfume, which helps to mask the unpleasant smell, but modern varieties can be made from ammonia dissolved in water and ethanol. They work by releasing ammonia gas, which when breathed in irritates the membranes of the nose and lungs. This triggers the body's natural reflex to inhale air, helping to increase the flow of oxygen to the brain, either waking you up or making you feel more alert.

Despite the name, smelling salts do not contain sodium chloride, the type of salt we use to flavour food, but they were once used in cooking. In the 19th century, before the arrival of baking powder and baking soda, ammonium carbonate was used to make bread and cakes rise. It's still used in a few traditional Scandinavian recipes today.

Although relatively harmless in small doses, inhaling large amounts of ammonia can cause lung damage

Organ donation

Discover the science behind the surgical swaps that save lives

It's often a misconception that those who require an organ transplant have in some way damaged their own body, for example, by smoking or drinking excessive alcohol. In some cases, genetics play a cruel role in the development of certain conditions, such as cystic fibrosis, meaning that transplants become the only treatment option. There are two main branches of the transplant process: organs donated by a living person, or those from a donor who has been declared brain dead.

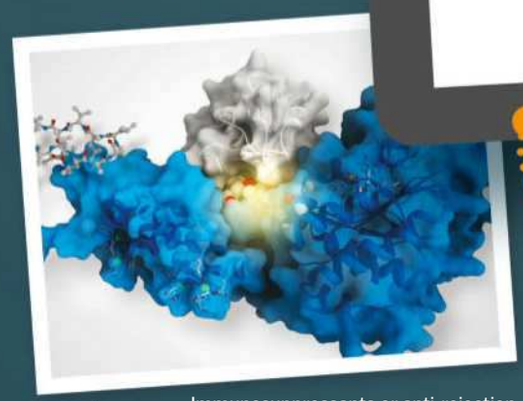
Living donors can obviously only donate organs that they can live without, such as a single kidney or part of their liver. However, vital organs such as the heart and lungs are recovered from a patient whose brain has irreversibly lost all function, known as brain death. Being declared brain dead could mean that vital organs are still viable and undamaged. In order to maintain their viability, a ventilator artificially pumps oxygen into the deceased patient's lungs. As the heart does not require the brain in order for it to beat, blood continues to circulate and deliver oxygen to the organs. These organs can then be removed by surgeons and transplanted into another patient who is a match.

Finding that match, however, can be a complicated undertaking and can differ depending on the organ. More than just a compatible blood type, factors such as tissue type, body size and the patient's condition severity can determine who receives organs.

Once a donor and patient are matched and the transplant surgery has been a success, an internal battle begins. Organ rejection can threaten the success of any transplant. This immune response occurs because a patient's system does not recognise the antigens (proteins) from the new organ. Instead, the new organ is viewed as a threat and the immune system attacks it. This can be prevented by trying to match a patient's blood as closely as possible to the donor's, and by using immunosuppressant medication to restrict the immune response.

From A to AB

The journey from diagnosis to donation and recovery



Immunosuppressants or anti-rejection medicines bind to proteins that trigger the immune response and block them

Diagnosis

There are a whole host of conditions where a transplant is necessary to treat a patient. Coronary artery disease, diabetes mellitus or cystic fibrosis are just some of the conditions that could warrant a transplant.

Transplant

Once the heart has arrived, the surgeon will open up the patient's chest, remove the damaged heart and connect the patient to a heart-lung bypass machine to circulate blood. Once the surgery is finished the new heart should start to beat with the flow of blood.

Recovery

During the process of physically healing, patients are monitored for infection or any signs of the organ being rejected by the body. Patients will have to take long-term immunosuppressant medicine to help prevent their own immune system from identifying the new organ as foreign.

Evaluation

After the point of diagnosis, a team of surgeons, nurses and coordinators will form a transplant team and carry out various tests to formulate the basis of what will result in a transplant match. In a living donation, the donor patient will go through several tests, both mental and physical, before they can donate.

Wait

Once on the transplant waiting list, patients will be notified if a match is found, which can be a lengthy period for many reasons. One is that organs have a limited time in which they can survive outside a living body, limiting the time frame of travel. For example, a kidney can last 24–36 hours, but a heart can only last around four to six hours.

Organ recovery

A team of surgeons will open up the deceased patient to extract the organ. In the case of a heart transplant, blood vessels are clamped and a heart preservation solution (HPS) is added before the vessels are cut and the heart is removed.

Preparation

Once an available match is found, the transplant team will evaluate the patient's suitability for surgery in a short time frame. With living donations of kidneys, cross-matching is carried out right up to the surgical procedure, which tests the immune response when blood from the donor and recipient are mixed.

Organs are put on ice after recovery and placed in a box designed to retain a cool temperature during transport to the recipient

Transplants through time

A history of the first successful human-to-human organ transplants

1954 Kidney

From one twin to another, Joseph E Murray and his transplant team successfully transplant the first kidney.

1967 Liver

A team led by Dr Thomas Starzl perform the first successful liver transplant at the University of Colorado, US.

1967 Heart

Surgeon Dr Christiaan N Barnard performs the first heart transplant at Groote Schuur Hospital, Cape Town, South Africa.

1983 Lung

The first single lung transplant is performed at Toronto General Hospital, Canada, by a transplant team led by Dr Joel Cooper.

In 2016 there were

78,519 kidney

27,218 liver

7,457 heart

5,432 lung

transplants globally*

*Data from the WHO-ONT Global Observatory on Donation and Transplantation. Correct as of 24 May 2018

ROCKET TRAVEL

Come aboard and find out why rockets are set to replace commercial aircraft

Words by **James Horton**

Anywhere in the world, in less than an hour." Elon Musk and his company SpaceX may have already revolutionised the way we utilise rocketry, but now they seek to use their technology to take us to Mars, the Moon, and even from city to city. And, quite amazingly, the price of enjoying this last application could cost the same as an economy airline ticket.

Known as the 'Big Falcon Rocket', or more simply as the BFR, SpaceX's upcoming spacecraft is set to satisfy all of our space-faring needs in one neat package. It will build upon the staggering success of their previous two rocket designs: the Falcon 9, which at the time of writing has successfully completed nine launches in 2018, and the Falcon Heavy, which first took to the skies in February of this year. These rockets have demonstrated for the first time in our history that not only can you land the first stage of a rocket booster on the ground safely, but you can reuse it. It is from this milestone that the BFR's goal to not only take people off-world, but also shuttle them around it, becomes viable and immensely promising.

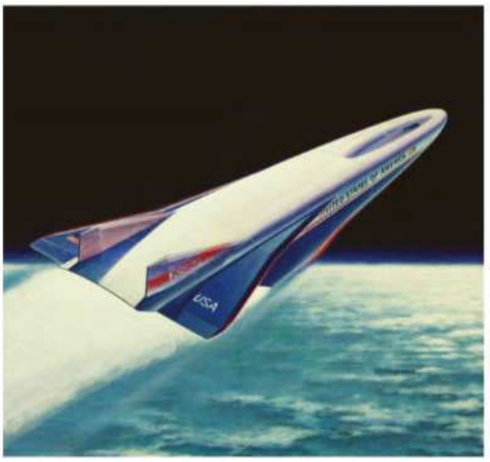
Standing at a mammoth 106 metres in total, the BFR will be composed of two major stages: a 58-metre-tall booster used to lift the vehicle into orbit, and a ship mounted atop the booster. This front portion will be equipped with 1,100 tons of additional fuel and boast a large, pressurised cabin for its city-to-city launches. This will give the BFR everything it will need to send its customers into sub-orbit and speeding around the globe. Here, passengers will be treated to not only arriving at their destination ludicrously quickly, but also to the majestic views of our planet that so far only a few lucky individuals have seen. Surely those sights alone will justify the cost of the ticket, with the fast arrival time becoming a rather big cherry on top.

It should be noted that SpaceX is not alone in its lofty ambitions. Not so far away another private company, Virgin Galactic, are creeping ever closer to their own sub-orbital flights. They plan for these to initially be sold for recreation and research, but also harbour long-term goals of trans-continental transport. Unlike the BFR, their two-component system involves a jet-powered carrier aircraft and an attached rocket-powered ship, which releases from the carrier craft and launches towards space once at altitude. Across the Atlantic, UK company Reaction Engines also dream of a vehicle that can soar from the runway to space as one whole unit. Their pioneering air-breathing SABRE engine aims to be an alternative to pure rocket power or jet engine/rocket hybrids like that of Virgin Galactic. Although this technology isn't currently as tangible as SpaceX's, it would almost certainly have incredible transport applications if it were to come to fruition.

In 1873, Jules Verne published a story about a man's attempt to race around the world in 80 days. It is a tale of great adventure, but one that pales in comparison to the journey that we have taken as a species in the years since its publication. We have ascended from the ground to the air, and from the air to the realm beyond. In fact, such is the staggering progress of our technological prowess over these years that by 2023, getting around the world in 80 *minutes* may not be quite quick enough.

Virgin Galactic's spacecraft will first be lifted to altitude by a carrier jet

Virgin's SpaceShipTwo will use rocket power to ascend from the skies into sub-orbit



Rocket travel would revolutionise global travel by dramatically cutting down journey times

Same goal, different approach

SpaceX's plan to utilise a sub-orbital vehicle for incredibly fast transport isn't a new one. Even decades earlier in 1986, when Ronald Reagan announced his plans to fund a vehicle that could get from Washington DC, US, to Tokyo, Japan, in two hours, it wasn't a novel idea. But the difference between SpaceX's ideas and those of the past has rested in their approach to the problem.

Reagan's government and NASA wanted to construct the National Aero-Space Plane (NASP) as a single unit that could act as both aircraft and spacecraft with a unique engine design. They had shied away from rockets due to their one-use-only restriction. But the answer to finding a commercial space-faring vehicle, as SpaceX has shown, didn't lie in finding a new way to generate enough thrust to get into orbit, but in a way to make the rocket stages reusable.

Designers anticipated that the NASP concept would travel at up to 25 times the speed of sound

Cruising
The BFR will launch at a safe distance from dense city centres, so a ship will ferry passengers to the launchpad from the mainland.

All aboard
Passengers will ascend and enter the 106m-tall vehicle. Inside, the pressurised compartment will be larger than an A380's main deck.

Cool ascent
Thanks to the engine's liquid oxygen and liquid methane fuel, the launch will feel relatively smooth and comfortable.

Smooth journey
Above our planet's dense atmosphere, passengers will be free from turbulence. They can relax and enjoy the awe-inspiring views of Earth from above.

City-to-city on the BFR

Hop aboard the Big Falcon Rocket and travel to anywhere in the world in under 60 minutes

Detachment
Its job done, the booster rocket will detach. The ship's Raptor engines will then ignite, boosting the aircraft to top speeds of 27,000kph.

Lift-off
52,700kN of thrust, provided by the booster rocket, will be used to lift the spacecraft out of the atmosphere.

Reusable
The first stage booster will be able to land autonomously. It will then be reserviced, refuelled and reused.

Journey times comparison

ROUTE	DISTANCE	FLIGHT TIME	BFR TIME
LA to New York	3,983km	5 hours, 25 min	25 min
Bangkok to Dubai	4,909km	6 hours, 25 min	27 min
Tokyo to Singapore	5,350km	7 hours, 10 min	28 min
London to New York	5,555km	7 hours, 55 min	29 min
New York to Paris	5,849km	7 hours, 40 min	30 min
Sydney to Singapore	6,288km	8 hours, 20 min	31 min
LA to London	8,781km	10 hours, 30 min	32 min
London to Hong Kong	9,648km	11 hours, 50 min	34 min
Sydney to Johannesburg	11,078km	13 hours, 35 min	37 min
Doha to Auckland	14,548km	17 hours, 43 min	45 min
Sydney to Zurich	16,576km	20 hours, 08 min	50 min
Rio de Janeiro to Hong Kong	17,709km	21 hours, 28 min	53 min

Sub-orbital transit
Unlike jet aircraft, the BFR will breach the atmosphere, continue its arc while in orbit, and make an atmospheric re-entry.

Weightlessness
After the ship's burn is complete, passengers will experience the feeling of weightlessness for a brief period as the aircraft coasts through space.

Comparable price
As the mechanical parts of BFR will be wholly reusable and its fuel incredibly cheap, passengers will pay similar prices to an economy airline ticket.

Re-entry
As the ship adjusts its orientation to slow its descent, the increased G-forces will cause passengers to feel several times heavier than usual.

Soft landing
Two engines will fire to bring the BFR to a safe and controlled stop at its destination.

"By 2023, getting around the world in 80 minutes may not be quite quick enough"

Motorcycle helmets

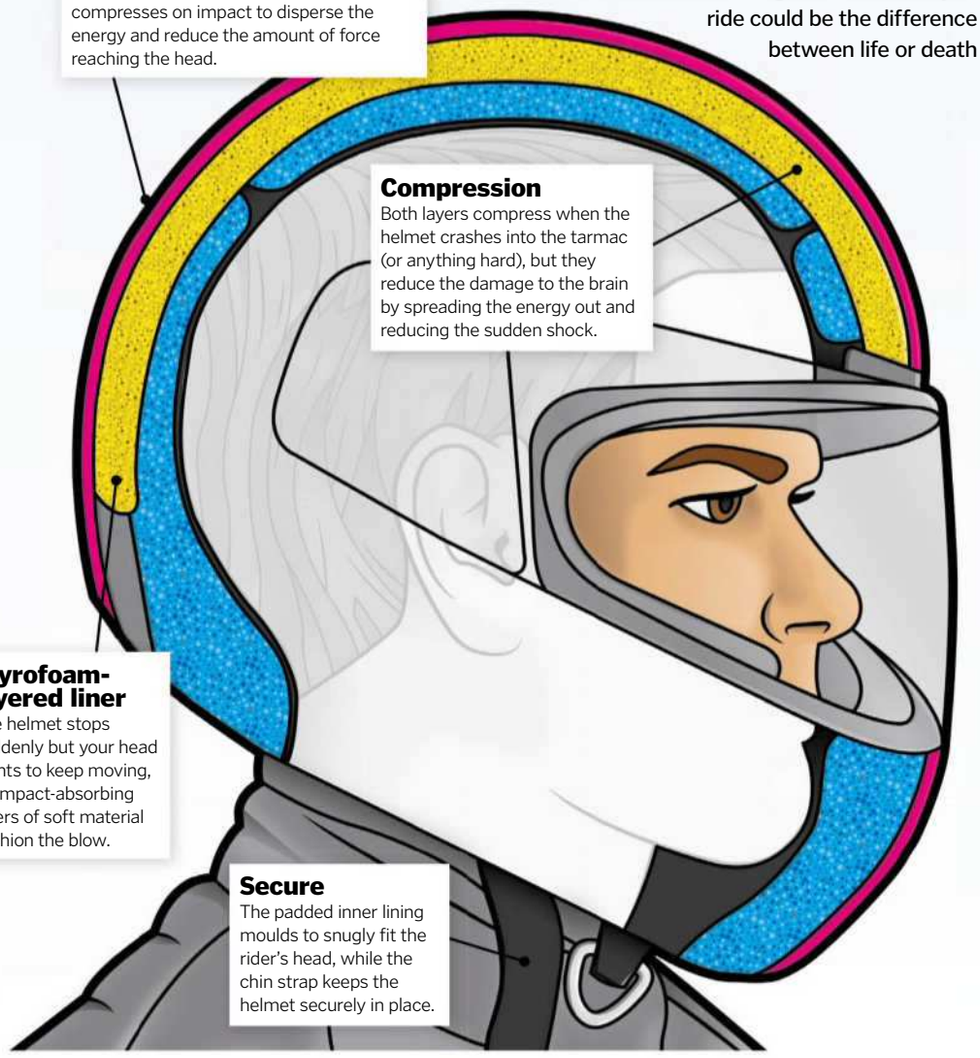
It's the law to wear a helmet, but why are they so important?

There are lots of vital pieces of clothing that a motorcycle rider needs to keep safe on the road: a thick jacket, leather trousers and strong gloves and shoes. But the most important piece of protective gear is the helmet, designed to help prevent fatal head injuries. When a rider is involved in a collision, their helmet hits the ground with full force, but it cushions the blow and protects the head and brain from the impact. For a helmet to work it is important that you wear the right size so it stays snug on your head and doesn't fall off in an accident, and always securely fasten the chin strap.

A helmet makes a ride more comfortable; it makes it easier to breathe and the visor prevents dirt getting into your eyes

Life-saving structure

Wearing a helmet while you ride could be the difference between life or death



Fibre-reinforced composite
The tough outer shell of the helmet is the first bit to make contact with the road. It compresses on impact to disperse the energy and reduce the amount of force reaching the head.

Compression
Both layers compress when the helmet crashes into the tarmac (or anything hard), but they reduce the damage to the brain by spreading the energy out and reducing the sudden shock.

Styrofoam-layered liner
The helmet stops suddenly but your head wants to keep moving, so impact-absorbing layers of soft material cushion the blow.

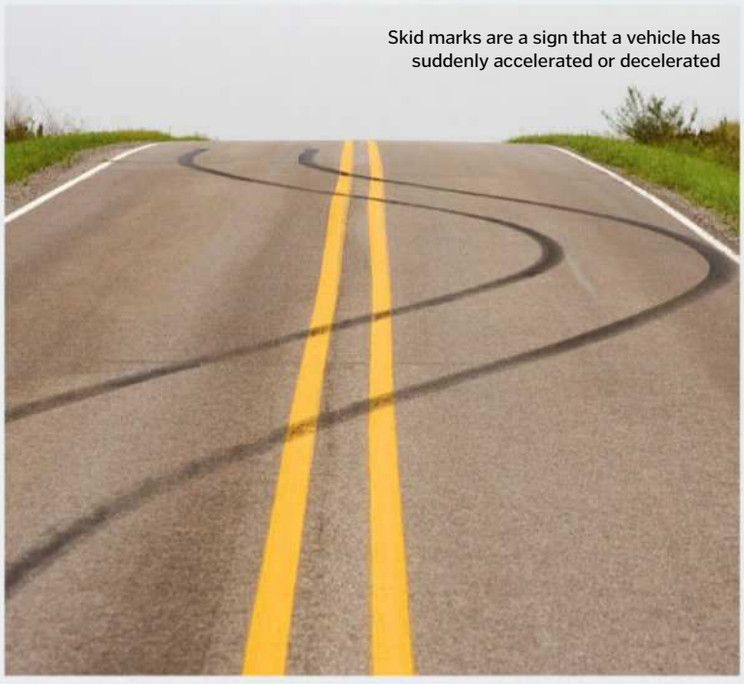
Secure
The padded inner lining moulds to snugly fit the rider's head, while the chin strap keeps the helmet securely in place.

Tyre marks

What causes those distinctive black marks on the road?

If you've ever watched a racecar skid around a track then tyre marks on the road are probably a familiar sight to you. The distinctive black marks can often be seen left behind on asphalt roads after an accident where the driver has had to brake suddenly. It might look like pieces of rubber from the tyre have been scraped across the road, but it's actually the asphalt that has been damaged from the friction. The friction caused by sudden braking or dramatic accelerating causes bituminous oils in the road to melt and rise to the surface.

Skid marks are important evidence when there has been an accident involving a vehicle, and detectives can determine a lot about the speed, direction and force exerted from the marks left on the road. You can do a bit of your own investigation too – it's easy to tell if the marks were caused by a car with an automatic braking system because the lines will be lighter due to the friction-reducing release-stop mechanism.



Skid marks are a sign that a vehicle has suddenly accelerated or decelerated

Nissan BladeGlider

This wild prototype proves electric cars aren't boring

Nissan is set to start 'challenging people's perceptions' with the new prototype BladeGlider to prove that electric vehicles can provide the same thrills as petrol-powered sports cars. Its tapered nose, wrap-around windscreen, narrow front track and three-seat cockpit make the BladeGlider look more like a jet fighter than any conventional sports car. With its sleek, futuristic design, the concept also boasts an amazing panoramic view. The reinforced open roof design with an integrated roll-over protection structure also offers security, which Nissan describes as combining "the exhilaration of an open-topped race car with the safety of a coupé."

Nissan have announced this prototype in line with their continued commitment to developing zero-emission vehicles, following on from their success with the practical and affordable Nissan Leaf. This 100 per cent electric sports car pushes the boundaries of electric driving to the limit and makes no compromise on speed. The finely tuned weight distribution makes the BladeGlider a master of acceleration, launching from 0–100 kilometres per hour in less than five seconds.

It can also take corners with startling precision. The narrow front of the car means less force is exerted on the thin front wheels – only 30 per cent of the car's weight is distributed over the front, meaning that the car can glide around corners with ease.

The Nissan BladeGlider prototypes come in two colour trims: Cyber Green and Stealth Orange

Nissan's first electric car

Nissan has a history of breaking boundaries and developing innovative technologies. The company released their first electric car in 1947 in response to the growing threat of gasoline shortages just after the Second World War. Oil in Japan was very scarce, but electricity was plentiful thanks to hydroelectric power plants.

Nissan, formerly Tachikawa Aircraft, utilised this power before producing the Tama. The car was built from wood, covered in a steel skin and powered by a direct current electric motor.

Despite its rudimentary design, it was able to travel about 65 kilometres on a single charge with a top speed of about 35 kilometres per hour. The company's gamble on such a novel invention paid off, and the car was used extensively until 1950, often as a taxi.

The Tama was the first of Nissan's electric cars, long before its successful descendent, the Leaf

Cooling system
The exclusive customised cooling system, designed just for the BladeGlider, keeps the entire system cool and running smoothly.

Doors
The rear-hinged doors open upwards and outwards, giving the vehicle a futuristic feel and making it easy to access the passenger seats – even in tight spaces.

Connectivity
Dual screens keep the driver informed via the onboard computer and provide information about the car's status, engine temperature and speed.

Inside the BladeGlider

The mechanics and electronics behind the sleek design keep this innovative prototype speedy, agile and aesthetic

Motor
Two 130kW electric motors generate 268 horsepower, giving the vehicle a top speed of approximately 190kph.

Power
Five 220kW lithium-ion battery packs provide power to the motors, and are located under the car to keep the centre of gravity low.

How airfields work

A smooth take off and landing requires the utmost synchronisation between teams on the ground and in the air

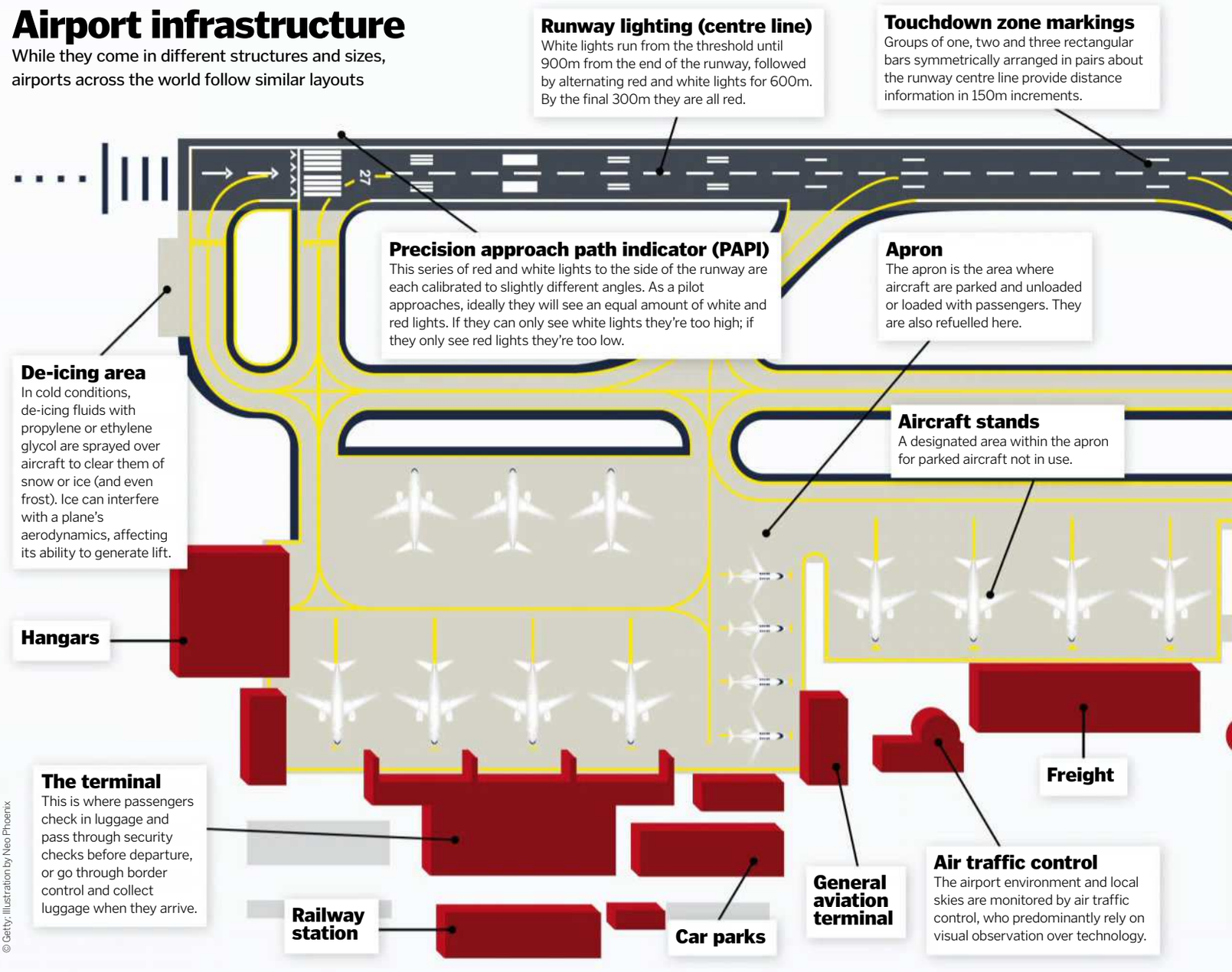
An airport has two main component parts: the airfield and the terminal. The terminal is the part with security checks and luggage processing. It's the area we as passengers are most familiar with as we wait patiently to board our flights. But once you leave the terminal to board your plane, you'll see the airfield; a complex series of runways, ramps and air traffic control systems that enable your plane to take off safely. It takes teamwork, attention to detail and advanced technology to keep everything running smoothly.

The crucial part of the airfield is the runway. In the days of early aviation, pilots could land almost anywhere – they'd come down from the skies with a bit of a bump, but their aircraft were slow and lightweight enough to land in a field or on a beach. Today, a modern runway is built to withstand a tremendous amount of force; with a 300- or 400-ton aircraft touching down at about 250 kilometres per hour, the structure has to be almost invincible. They are designed to be elastic, with reinforced mesh between layers of concrete or asphalt to distribute the load.

Air traffic control teams coordinate all the take offs and landings to make sure all flights start and finish safely. With some airports managing over 2,500 flights a day, this is no easy feat. While technology provides operators with crash warning systems and advanced cockpit display systems using GPS, traffic sensors and NASA software, it's the work of air traffic control to prevent incidents on the ground. With around 10,000 planes in the skies around the world at any one time, pilots and air traffic controllers have to cooperate like a well-oiled machine.

Airport infrastructure

While they come in different structures and sizes, airports across the world follow similar layouts



Every jet to leave or arrive at an airport is processed through air traffic control so they know exactly which planes are on the airfield and in the surrounding skies

5 FACTS ABOUT AIRPORTS

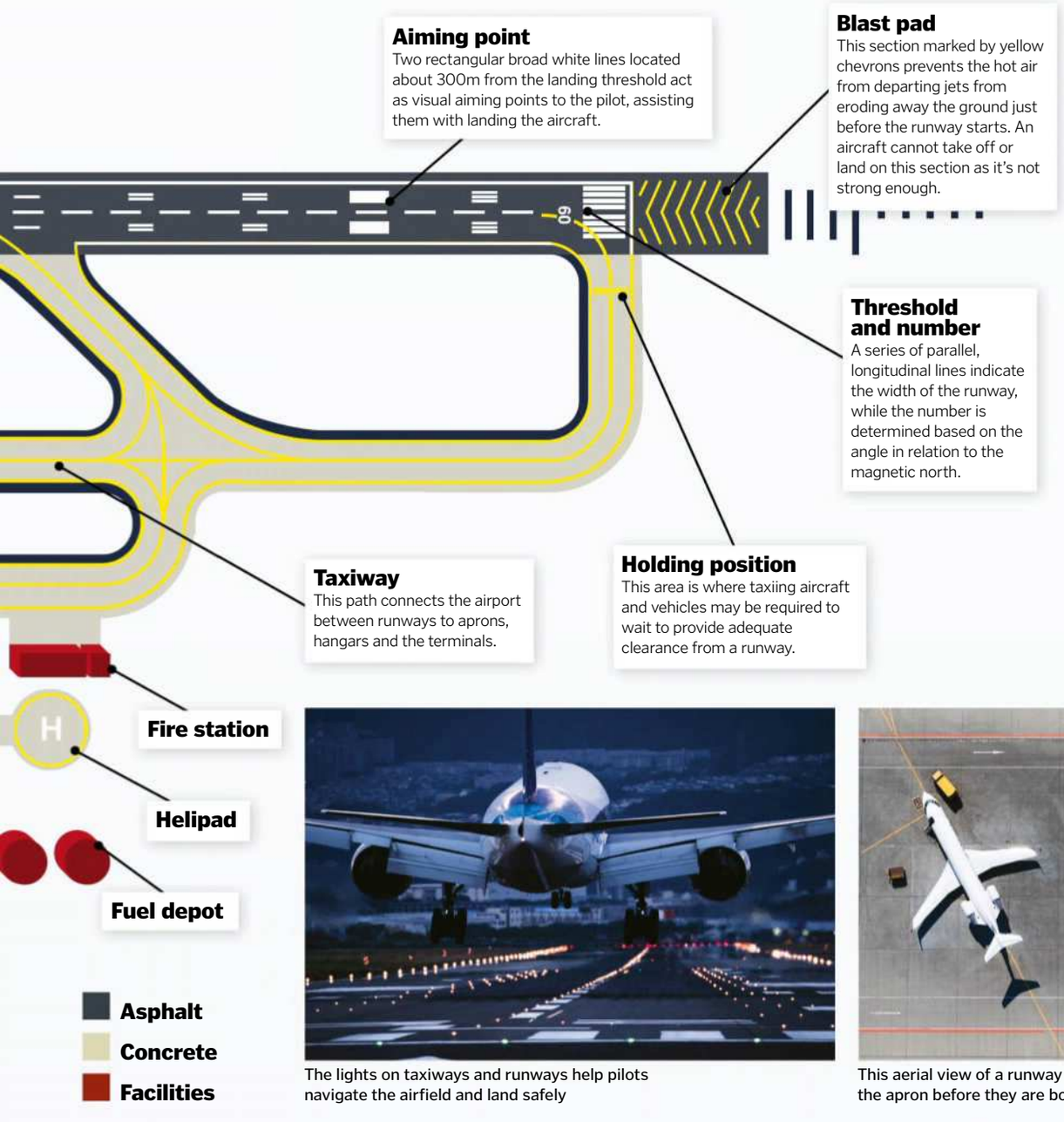
1 Shortest runway
The shortest commercial runway in the world is just 400 metres long and is found at Juancho E Yrausquin Airport on the Dutch Caribbean island of Saba.

2 Air traffic control
Air traffic control use satellites to track aircraft, but they mostly rely on their own vision from their panoramic windows when directing planes on the ground.

3 Runway regulations
Runways are built to very precise standards. They have to meet every single specification of a 194-page document issued by the International Civil Aviation Organization in order to ensure the utmost safety.

4 Multiple runways
Large airports have runways facing in lots of different directions. When a plane is set to take off or land, air traffic control will select a runway aligned with the wind direction to minimise risk.

5 Digital air traffic control
Hi-tech air traffic control towers are slowly being rolled out around the world. The new digital systems rely on a series of sensors and HD cameras to make airfields even safer.



The lights on taxiways and runways help pilots navigate the airfield and land safely

This aerial view of a runway shows planes lined up waiting in the apron before they are boarded and ready for take off

The Future Starts Here

100 projects shaping the world of tomorrow

Supported by **Volkswagen Group**

V&A

UNTIL 4 NOVEMBER 2018

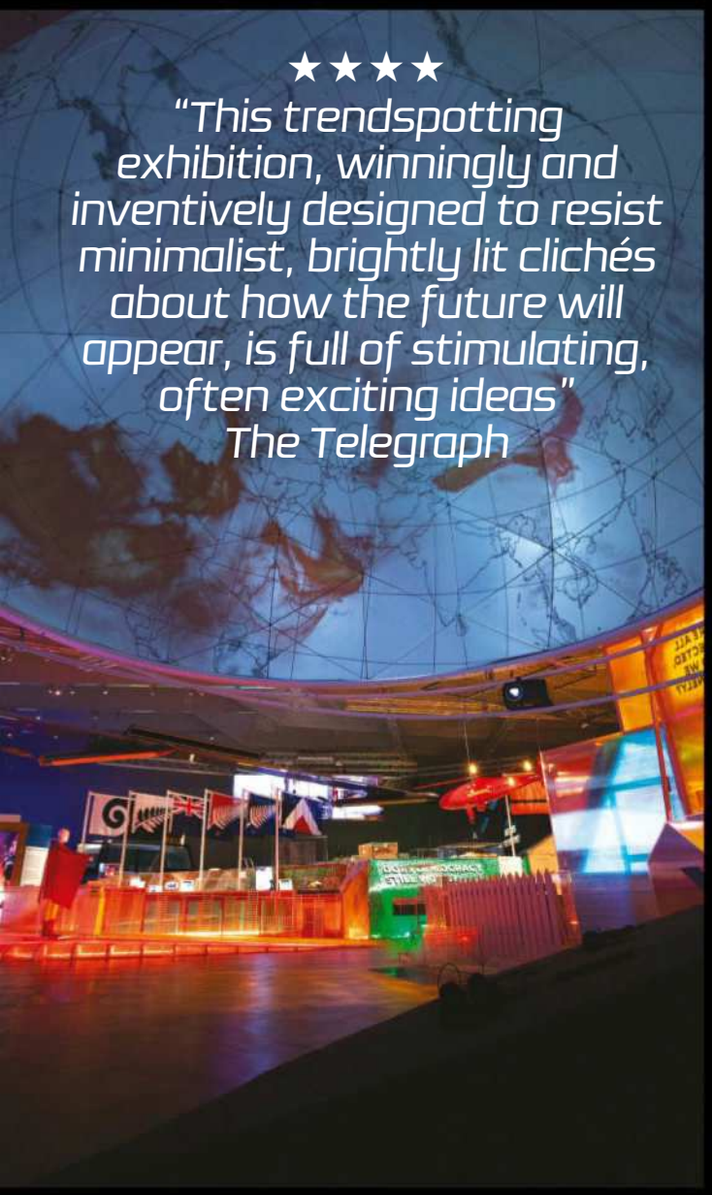
The world of tomorrow is shaped by the designs and technologies emerging today. This thought-provoking exhibition brings together more than 100 objects either newly released or in development that point towards where society might be headed. From smart appliances to satellites, artificial intelligence to internet culture, this "mind-boggling, parameter-expanding display" (*The Times*) may seem straight out of science fiction, but these objects are real, produced by studios, universities and laboratories around the world.

Guided by ethical and speculative questions, we invite you to consider what impact these objects might have on your body, your home, your work, your planet – ultimately your life and death. How could they affect the way you live, learn and even love?

The undeniable physical reality of these objects may give the impression that the future is already fixed. But new things contain unpredictable potentials and possibilities, often unanticipated even by their creators. It is up to us – as consumers, as citizens and even as a species – to determine what happens next. While the objects here suggest a certain future, it is not yet determined.

The future we get is up to us.
The future starts here.

V&A South Kensington vam.ac.uk/future V&A Members go free



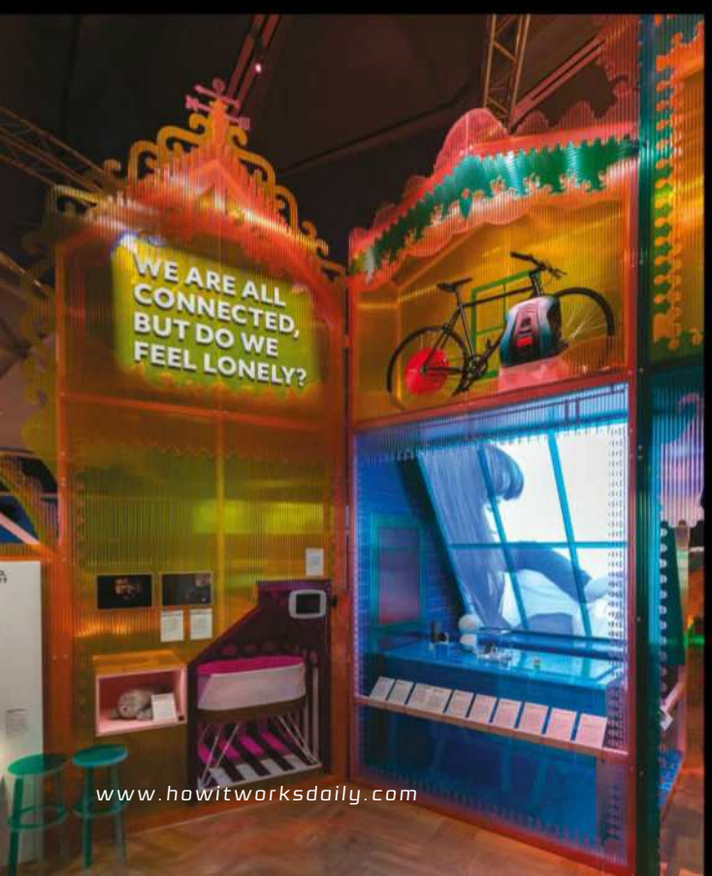
★★★★

"This trendspotting exhibition, winningly and inventively designed to resist minimalist, brightly lit clichés about how the future will appear, is full of stimulating, often exciting ideas"
The Telegraph

Unless otherwise stated, all images courtesy of Victoria and Albert Museum, London

Right
The SEDRIC (SElf DRIving Car) concept, developed by Volkswagen Group Future Centre Europe

Below right
The Berkeley Robot for the Elimination of Tedious Tasks (BRETT) developed by the University of California, Berkeley and Arizona State University, sponsored by the United Technologies Research Center and the National Science Foundation



"Stimulating, inspiring, exciting and challenging" The Times

RISE OF THE ROBOP

Could the future for man's best friend be more chrome than canine?

Words by **Scott Dutfield**

ETS

During the 1990s and early 2000s, digital or robotic pets were at the top of most children's Christmas lists. From the pocket-sized Tamagotchi to the spirited Furby, these toys gave us a glimpse of what we could expect from developers in the future. Since our interests were piqued over 20 years ago, the idea of a robotic pet has far surpassed the realm of being just a toy, with many having become a functional and useful piece of technology. Earlier this year at the CES exhibition in Las Vegas, Sony showcased their latest recreation of the 90s hit robot dog, Aibo. Almost unrecognisable compared to its original form, the new Aibo is arguably the most technologically advanced robotic pet on the market. Jam-packed with sensory, locomotive and automated technology, this robot dog has raised an important question: Could our animal companions ever be replaced by robots?

CREATING A COMPANION

When it comes to robotic animals, there is a significant difference between what is a toy and what you could truly consider a pet. One key difference lies in their level of autonomy and accompanying artificial intelligence (AI). The majority of robopet toys of the 90s and 2000s had been programmed with limited abilities. They could give a set response to sounds or be controlled remotely by their user to follow commands. Therefore it's hard to imagine that

The MiRo is being developed as a companion and to aid those in later life

the unique characteristics of our beloved pets could ever be reproduced in a robotic alternative. However, with the introduction of AI to life-imitating pets, their ability to learn and develop a 'personality' could make them much more than just a toy.

Hollywood blockbusters often associate artificial intelligence with androids determined to overthrow the human race. However, the fundamentals of AI aren't malevolent. At its core, AI is simply the ability for a computer program or robot to carry out tasks that humans would associate with intelligence. Examples of AI could include the ability to learn from experiences, solve problems or recognise individuals based on voice or facial analysis.

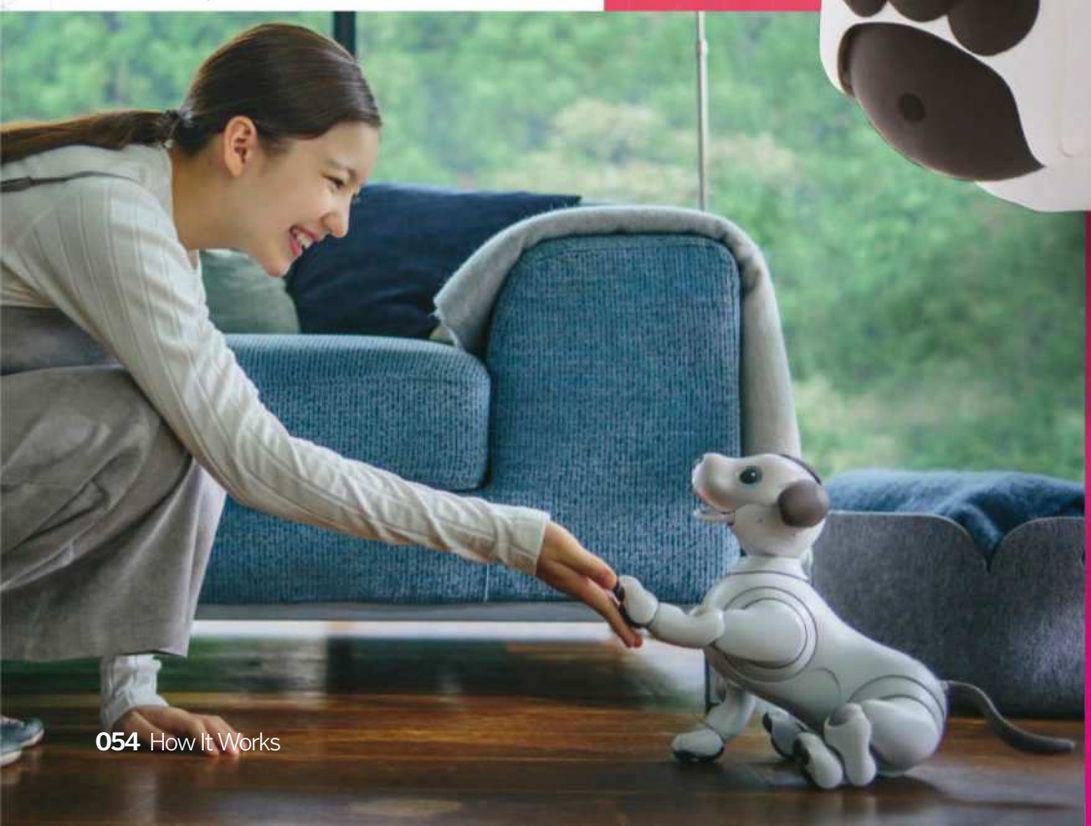
Aibo, for example, is brought to life through installed intelligence alongside mechanical characteristics. It can respond to a situation, learn to perform tricks, play on its own, navigate around a room, and much more thanks to its AI brain. It's this memory stick mind that lets Aibo grow and mature the more it is interacted with. Much like any conventional pet, Aibo also responds to being touched and petted, with several sensors placed around its body. If you own a dog you know that if you are the one that feeds them, walks them and plays with them the most, you are often the one that gets the most puppy love.

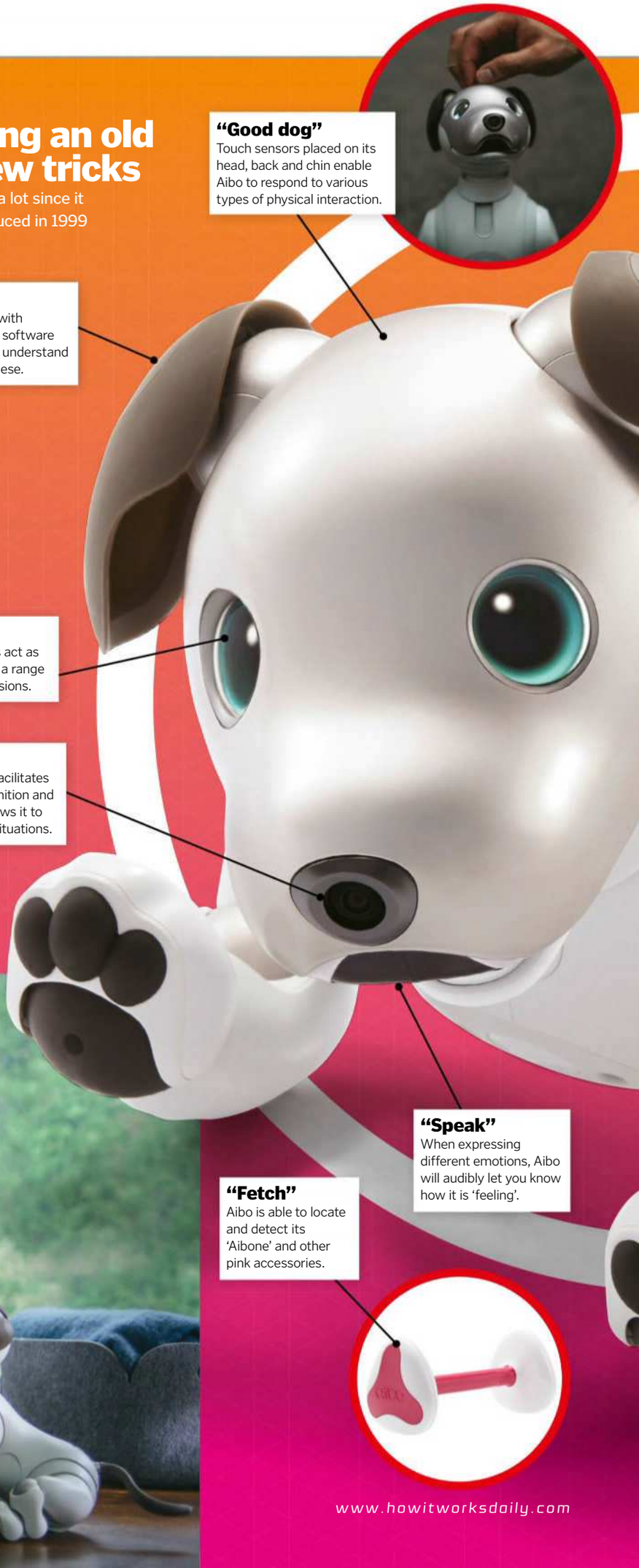
This is a natural quality that developers have incorporated into their designs. Aibo's AI technology enables it to differentiate between members of the family, and those that give it the most attention grow to be its favourite.

Aibo could offer families a chance to enjoy the benefits of a pet without some of the downsides

Teaching an old dog new tricks

Aibo has learnt a lot since it was first introduced in 1999





"Good dog"
Touch sensors placed on its head, back and chin enable Aibo to respond to various types of physical interaction.

"Aibo"
Aibo is equipped with voice-recognition software and can currently understand English and Japanese.

"Look"
Two OLED displays act as eyes, able to show a range of different expressions.

"Heel"
A built-in camera facilitates Aibo's facial recognition and navigation and allows it to react to different situations.

"Speak"
When expressing different emotions, Aibo will audibly let you know how it is 'feeling'.

"Fetch"
Aibo is able to locate and detect its 'Aibone' and other pink accessories.

"Bed time"
This hi-tech robopet can play and interact for around two hours before it needs to take a literal power nap at its docking station.

"Walk"
Aibo has built-in simultaneous localisation and mapping (SLAM) technology, which enables it to familiarise itself with its surroundings.

"Aibo's AI can differentiate between members of the family – those that give it the most attention become its favourite"

ROBOPETS OF THE PAST

Furby
Making its debut at the American International Toy Fair, Furby was able to progress from its native language of 'Furbish' and learn the tongues of its owner over time.

Aibo ERS-110
The first generation of Aibo dogs gave us a glimpse into the future. This robopet required its owner to interact with it in order for it to grow from puppy to adult.

Tekno
Before the days of robotic pet autonomy, Tekno expressed 'emotions' using various lights and motors around its body. It proved a hit, selling over 40 million units worldwide.

Poo-Chi
Created by Sega toys, Poo-Chi was a particularly colourful robopet able to follow certain commands from its owner. It could also bark 'songs' at the press of a button.

Aibo isn't, of course, the only robotic pet to use advanced technology. CHiP (Canine Home Intelligent Pet) is a dog with the same intentions as Aibo, however, this mechanical mutt has traded walking for wheels. Released back in 2016, CHiP received a lot of media attention as a result of its developer's claim that it could develop a personality. While it's less autonomous than Aibo, CHiP allows owners to approve its behaviour via their own SmartBand accessory. This device allows owners to communicate with CHiP to deliver commands and even tailor its behaviour. By 'liking' CHiP's actions through the band, this robopet can begin to learn how to (and how not to) behave, in a similar way to training a real-life dog.

Robotic pets have been designed to be an entertaining version of their living counterparts, and they offer us a new type of companion. Our technological demand for instant information may mean that products like Aibo or CHiP could have smart-home assistants like Amazon's Alexa incorporated within them in the near future, making the owner a modern-day Dr Doolittle. However, there are robopets out there that are enriching people's health as well as their homes.

PET THERAPY

Although living pets offer a great amount of affection and happiness to their owners, they come with responsibilities that not everyone can commit to. There has been an increased use of robotic pets among the elderly and those with disabilities as companion and therapy pets.

Straying away from the more popular dog or cat design, PARO is a robotic seal pup that offers support in hospitals and care facilities. This robot is currently being used as a tool to aid patients suffering from dementia with social interactions. PARO is equipped with multiple sensors and responsive animatronics to replicate the movements of a living pet, but it remains relatively sedentary to keep patients calm and happy.

Other companies, including Hasbro, have also created companion robots to replicate both cats and dogs in order to serve the same purpose as PARO. Projects such as MiRo are currently in development to produce autonomous robots that can monitor our health. Created by Consequential Robotics, MiRo aims to reassure its owners that they are not alone in a medical crisis. "We design robotic systems that will go into people's homes to help them look after themselves better. [They're] specifically helpful for old people. The key reason people go into residential care is the fear of falling; that you will fall over and no one will be there," said co-founder Sebastian Conran. This is where MiRo could be of assistance by alerting the authorities when it detects a problem.

"What we can do is program MiRo to respond if you're happy or sad as it has facial recognition. It can see what faces you are pulling or if you're in the process of having a stroke," Conran continues. Research has shown that pets both living and robotic can offer therapeutic help to their owners, but what about their use as a medical monitor? MiRo is being developed as a barking health checker as well as a companion.

"It can transmit information and understand what the wristband around your wrist is saying, whether your body temperature is a bit hot or cold. It can say whether your blood oxygen level is low or if your heart rate is elevated or not present. It can monitor basic vital signs pretty accurately," explains Conran.

It seems that robotic pets may have a place within future households as a source of support, entertainment and potentially even security – roles that a living counterpart can't necessarily offer. However, as far as answering the question of whether they could replace our furry friends, we have a long way to go before we see anything that could compete with the real deal.

PARO is a therapeutic robo-pet based on a harp seal pup. It can provide comfort to dementia patients

Above and above left: Hasbro's Companion Pets have been designed to bring joy and comfort to the elderly, without the added responsibilities or expenses of care

ALL BARK AND NO BITE?

Robopets can be extremely useful, but are they a substitute for the real thing?

CHiP is a consumer robot and family pet that can be trained like a living dog

✓ Training
Some pets are defiant and unpredictable, while a mechanical pet's behaviours can be programmed.

✗ Affection
Sometimes after a stressful day you might want a warm, fluffy cuddle from your beloved pet. Hugging a rigid metal body isn't really the same.

✗ Agility
Though fun to play around the house with, robopets remove the fun of going for a walk in the woods or playing at the park.

✓ Allergies
Unfortunately, there are many people that would like to have a pet but simply can't because they are allergic. Robopets remove that worry.

✗ Energy
Robotic pets are only active as long as they have charge, but the same could be said for living pets. However, Aibo can only play for two hours per charge, and living dogs can definitely run for longer than that.

✓ Clean
One of the biggest benefits of a robotic pet is that it comes out of the box already housetrained, meaning no unfortunate accidents.

The Seattle Space Needle

Created for the World's Fair theme 'The Age of Space' in 1962, the construction of the Space Needle was out of this world

Towering above the Seattle skyline is the iconic Space Needle. If you've never been to the US city then you might recognise it from the title sequence of the hit show *Frasier* or as a cutaway feature in the medical drama *Grey's Anatomy*. Before becoming a city showstopper, the Needle started out as a simple doodle on a restaurant napkin or placemat back in 1959.

While visiting Stuttgart in Germany, Edward Carlson, chief organiser of the 1962 World's Fair, sketched a design of a Seattle building to feature centre stage and host the Century 21 Exposition. Partnering with Seattle architect John Graham, the two transformed the initial skyscraper scribble into a towering reality.

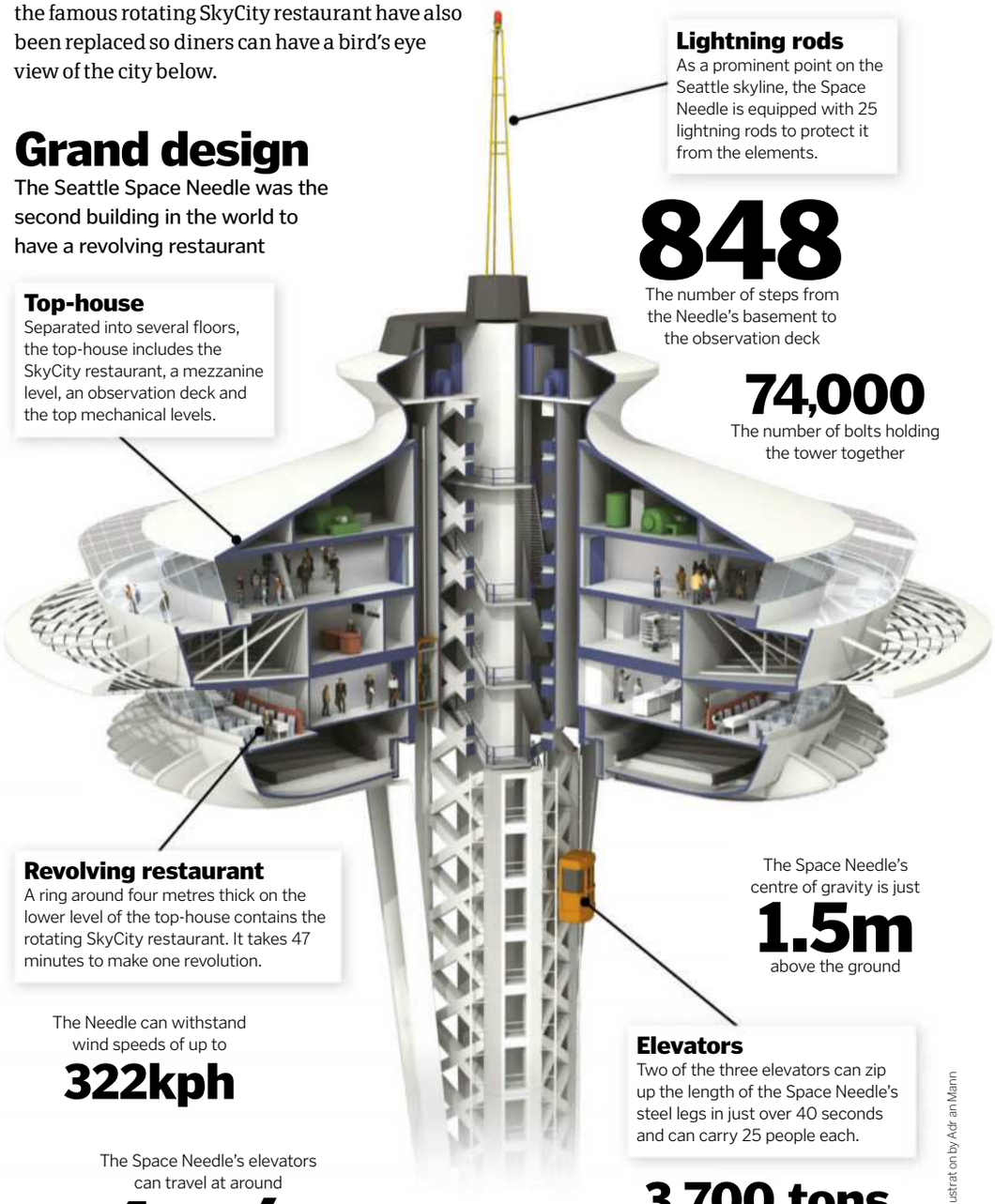
After acquiring a plot of land of nearly 1,340 square metres, a hole over nine metres deep and 36.6 metres wide was excavated to provide the foundation of the building. To fill the massive hole, 467 vehicles poured 5,600 tons of concrete and 250 tons of reinforced steel into its foundation – at the time the largest ever concrete pour attempted on the West Coast. A set of steel tripod legs was then erected, which support the famous flying-saucer-style top-house. Construction was completed in a record-breaking 400 days, in time for the World's Fair.

Today, 56 years after it was built, the Space Needle is getting a transparent transformation. Hoisted nearly 159 metres above the street below, 48 glass panels – each weighing more than a ton – will replace the exterior structure of the observation deck. However, the observation deck isn't the only thing going glass; the floors of the famous rotating SkyCity restaurant have also been replaced so diners can have a bird's eye view of the city below.

During its unveiling at the 1962 World's Fair, the Space Needle was visited by an estimated 2.65 million people

Grand design

The Seattle Space Needle was the second building in the world to have a revolving restaurant



Lightning rods
As a prominent point on the Seattle skyline, the Space Needle is equipped with 25 lightning rods to protect it from the elements.

848
The number of steps from the Needle's basement to the observation deck

74,000
The number of bolts holding the tower together

Top-house
Separated into several floors, the top-house includes the SkyCity restaurant, a mezzanine level, an observation deck and the top mechanical levels.

Revolving restaurant
A ring around four metres thick on the lower level of the top-house contains the rotating SkyCity restaurant. It takes 47 minutes to make one revolution.

The Space Needle's centre of gravity is just
1.5m
above the ground

The Needle can withstand wind speeds of up to
322kph

Elevators
Two of the three elevators can zip up the length of the Space Needle's steel legs in just over 40 seconds and can carry 25 people each.

The Space Needle's elevators can travel at around
4m/s

3,700 tons
The weight of the entire Space Needle structure

The revolving restaurant begins its ascent to form the Space Age top-house in August 1961

Inside the Samsung Galaxy S9+

We take a look at what's happening inside Samsung's latest smartphone

The race for smartphone supremacy never stops, with the leading companies releasing new models every year to try and bring amazing new features to their customers. Samsung's latest offering brings a variable aperture lens to its camera system, something normally reserved for larger, dedicated cameras. The trick is that Samsung has included two tiny rotating discs into its camera that can open and close the aperture to allow more light into the lens. That means that you can get better low-light photos and still use the same camera to take everyday photos on sunny days. In fact, at f/1.5, the Galaxy S9+ has the widest aperture of any phone, so it's currently the market leader.

However, that's not the end of the innovation. The new biometric scanning cameras that face you when you pick up the phone can now be used to turn your face into an emoji! It's as simple as looking at the screen and letting the phone analyse your features. Soon, a cartoon version of yourself will appear in front of your eyes, meaning you can send personalised reactions to your friends. There's also a slow-mo camera that lets you record video and reduce the speed; auto-translate software that can show you live translations of words in the world around you; and a quick unlock system that uses your face and eyes as a password. It's a lot of tech for one small phone (especially when it's got such a big display), so let's find out how it all fits in there.

Thanks to the wider aperture lens you can get better shots even in low light

We lift the lid on the Galaxy S9+

How Samsung has packed so much advanced tech into such a small space

Colour range
The Galaxy S9+ is available in four main colours: Midnight Black, Lilac Purple, Coral Blue and Titanium Grey.

Fingerprint scanner
This small fingerprint scanner sits on the back of the phone just below the two cameras for another security option.

Dual camera
There are two rear cameras on the S9+. The first is the smart dual aperture camera, while the other lets you take lovely portrait photos.

Selfie camera
This front-facing eight-megapixel camera points at your face so you can take selfies. Smile!

Iris camera
The iris camera scans your eyes then combines this information with a facial scan to confirm your identity before unlocking the phone.

"The new biometric scanning cameras can turn your face into an emoji"

Motherboard
This is the main brain of the phone, housing the processor, memory and storage.

Display
The edge-to-edge, 6.2in AMOLED display packs in a whopping 529 pixels per inch.

Battery
The S9+ has a 3.85V, 3500mAh battery. That's up to 25 hours of talk time or 15 hours on Wi-Fi.

Daughterboard
This small board houses components like the charging port, making it cheaper to replace if it breaks.

Surround-sound speaker
The earpiece on the Galaxy S9+ doubles as a speaker to give you a more rounded sound experience.

Biometric scanners
This tiny board houses the IR blaster and sensor that are used to scan your face and unlock your phone.

When paired with the facial recognition and fingerprint scanner, the iris scanner makes this a very secure phone

Personalise your emojis

The tech in the Galaxy S9+ allows the phone to draw an accurate image of your face, and it can use it to animate an emoji version of yourself onscreen to send to your friends! The IR blaster fires hundreds of tiny beams of infrared light at your face that are invisible to the human eye. The IR sensor then tracks where they land to form a 3D image of how your face appears. Software then takes this information and works out what kind of face you're pulling before creating a similar expression on your animated avatar. It sounds complex, but the basic idea is that if you smile, your emoji will do the same in front of your eyes. It's that easy!

Hi-tech referees

Discover the advanced technologies making their World Cup debut in Russia

The origins of football are clouded in mystery, but the game as we know it today was officially codified in 1863. The first World Cup was played in 1930, and red and yellow cards were introduced at the 1970 World Cup. 2018 is a year in which yet another footballing innovation will become part of the beautiful game – Video Assistant Referees (VAR).

Video replays to assist referees with decision making have been used in rugby, cricket and tennis for many years, but football has resisted bringing in the technology until recently, with many concerned it would interrupt the natural flow of the game. Goal-line technology was first used at the 2012 Club World Cup, but technology to help referees make decisions on penalties, red cards and cases of mistaken identity only came into use in the Dutch Cup in 2016.

There are several systems, including Hawk-Eye and GoalRef, that either use cameras or magnetic fields to capture contentious goals that the referee and linesmen may have missed. But now VAR technology will also be used to pick up on other incidents during play, such as whether a red card is justified or not.

The early days of VAR have been beset by problems, mainly as a result of confusion and misuse rather than issues with the technology. But if VAR is successful at the World Cup it could herald yet another innovative age for football.

Making a VAR call

The steps taken on and off the pitch during a VAR decision

1 Alert

The referee on the field can ask to have another look at a particular incident if they think they got it wrong. The VAR team can also alert the referee to something that has been missed.

2 Review

The VAR team watch the game from monitors that show slow-motion replays from various angles. The VAR then advises the referee via a headset on what they have seen.

3 Decision

The referee can review the footage on a pitch-side screen or accept the VAR's information. The referee will then announce if the original decision stands or if it has been overturned.

When is it used?

Has a goal been scored?

A referee can use VAR to determine if there's been a violation prior to the goal that means the goal should not be awarded.

Should it be a red card?

Referees can have another look at potential red card decisions.

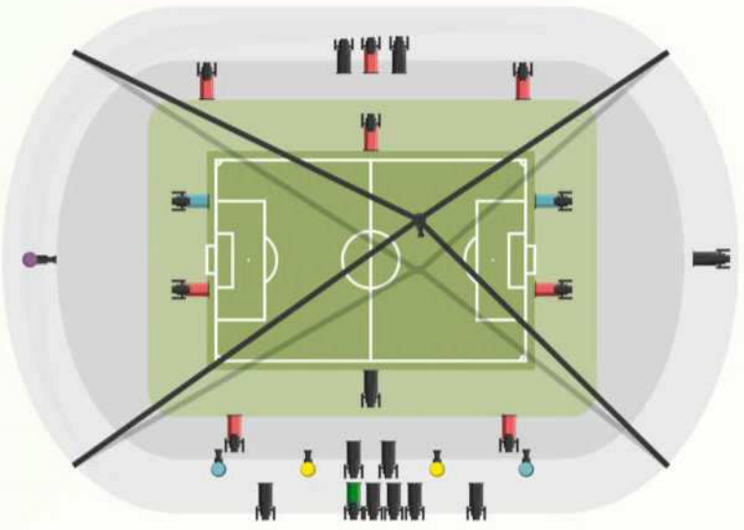
Should a penalty be given?

A referee can award or rescind an awarded penalty after reviewing footage.

Has the wrong player been sent off?

If there's been foul play but the wrong player gets the blame, the VAR can alert the referee to the mistake.

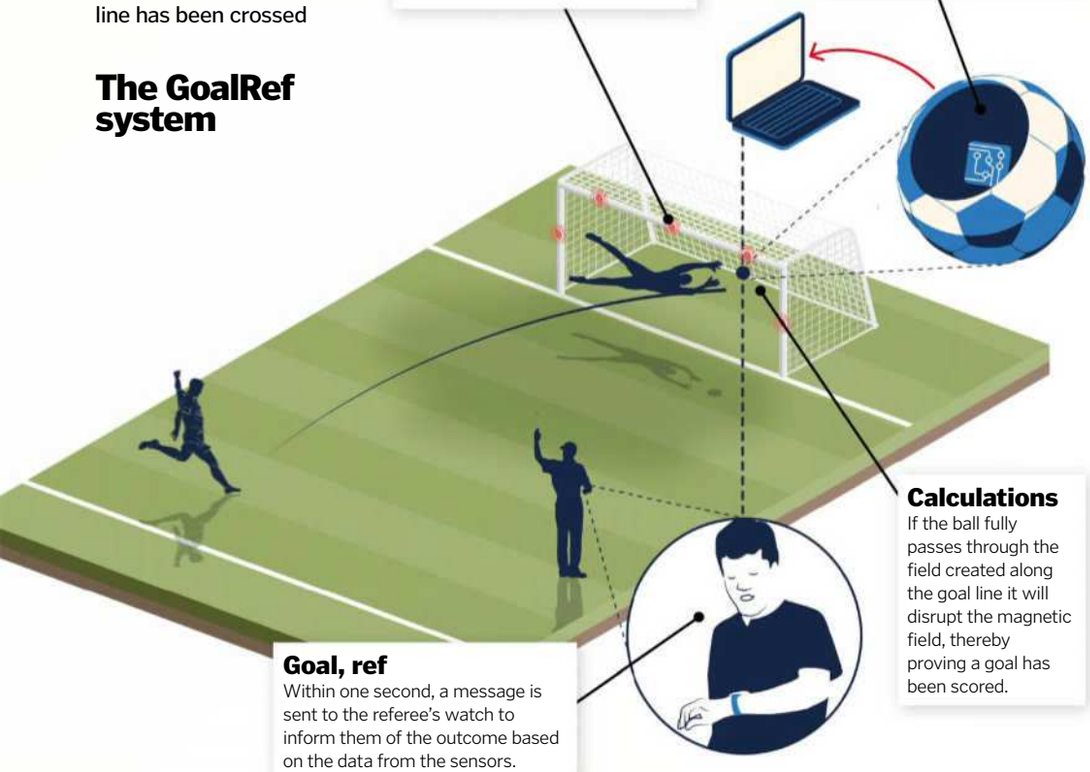
"2018 is a year in which yet another footballing innovation will become part of the beautiful game"



Goal-line technology

How referees can tell if the line has been crossed

The GoalRef system



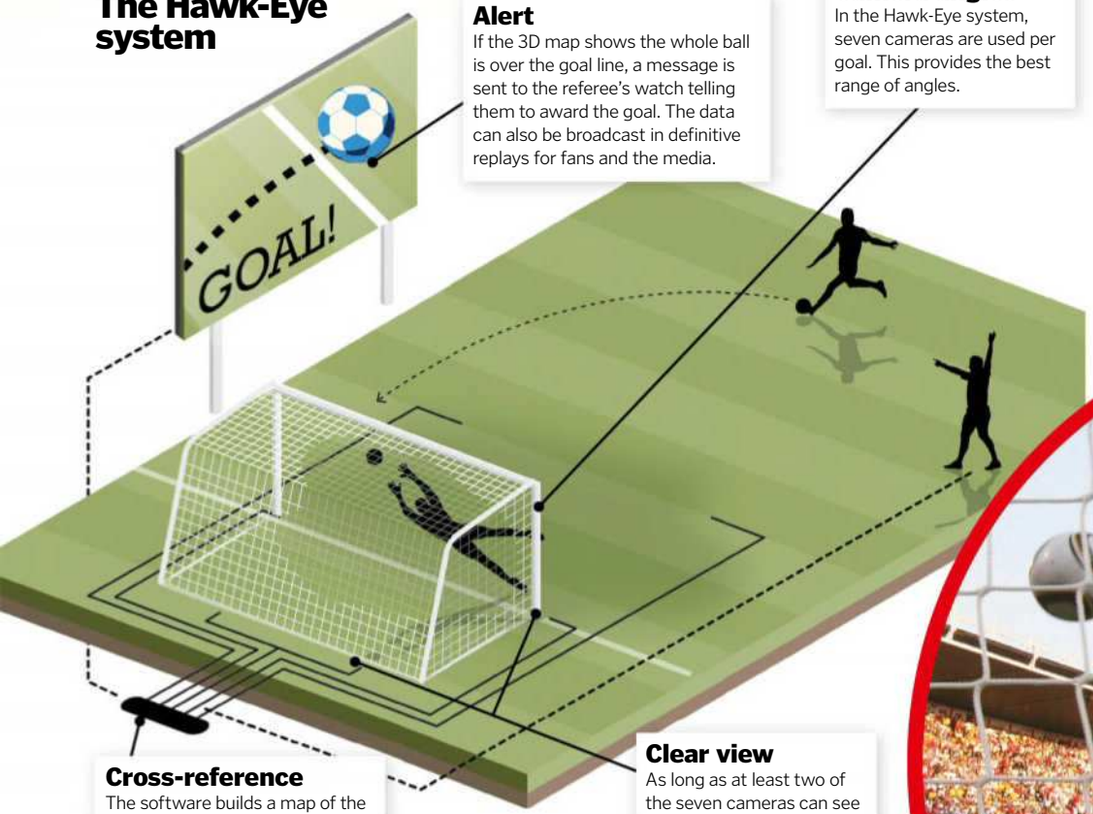
Magnetic field
Cables are laid underground around each goal and antennae are set up around the post and crossbar to generate a magnetic field.

Magnetic sensors
The ball contains magnetic sensors that interact with the goal's magnetic field.

Calculations
If the ball fully passes through the field created along the goal line it will disrupt the magnetic field, thereby proving a goal has been scored.

Goal, ref
Within one second, a message is sent to the referee's watch to inform them of the outcome based on the data from the sensors.

The Hawk-Eye system



Alert
If the 3D map shows the whole ball is over the goal line, a message is sent to the referee's watch telling them to award the goal. The data can also be broadcast in definitive replays for fans and the media.

Camera angles
In the Hawk-Eye system, seven cameras are used per goal. This provides the best range of angles.

Cross-reference
The software builds a map of the ball and the goal line to determine if the whole ball has crossed it.

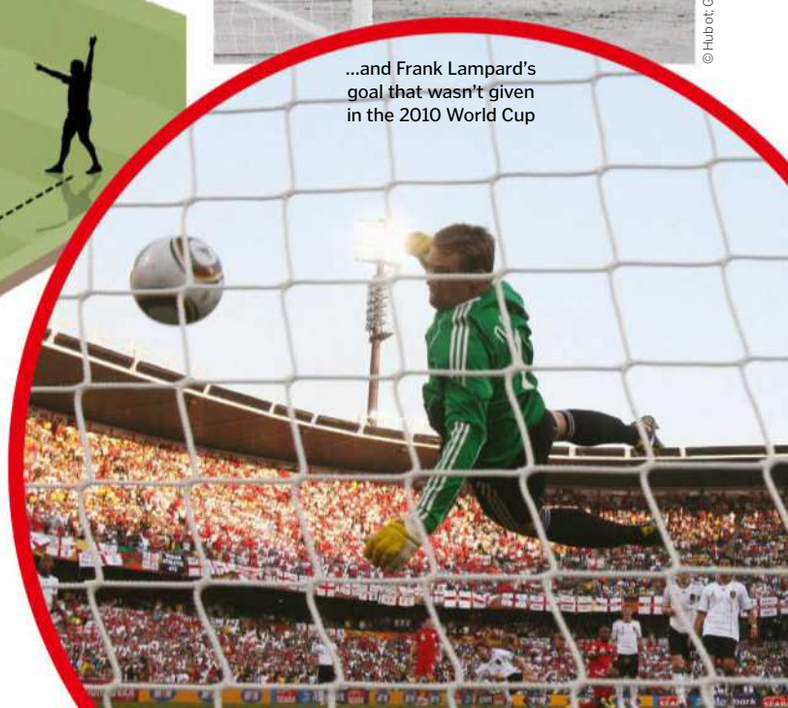
Clear view
As long as at least two of the seven cameras can see the ball, an accurate ball position can be determined.

Ref watch

All eyes may be on the referees at the World Cup, but the referees' eyes will be on their Hublot smartwatches. The Big Bang Referee smartwatch is the official timepiece of the 2018 World Cup and will be worn by all the referees. The consumer version features the flags of all 32 competing countries around the rim, allowing you to turn the dial and access information about that team. It also alerts you to goals, cards and substitutions. The referee model does all that, as well as being linked to the goal-line technology. It is powered by Android and also boasts a 287ppi AMOLED screen.

The Big Bang Referee smartwatch will keep you up to date with all 32 teams

Two England v Germany incidents are used to support the addition of goal-line technology. Geoff Hurst's disputed goal in 1966...



...and Frank Lampard's goal that wasn't given in the 2010 World Cup

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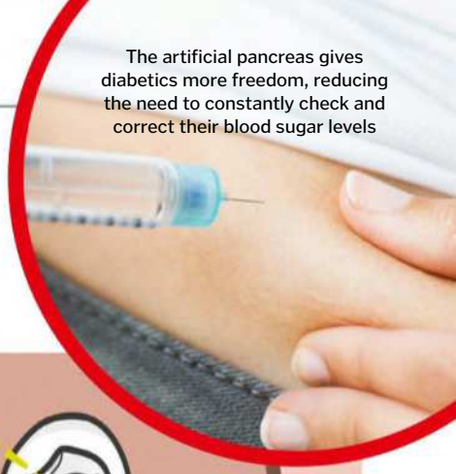


The artificial pancreas gives diabetics more freedom, reducing the need to constantly check and correct their blood sugar levels

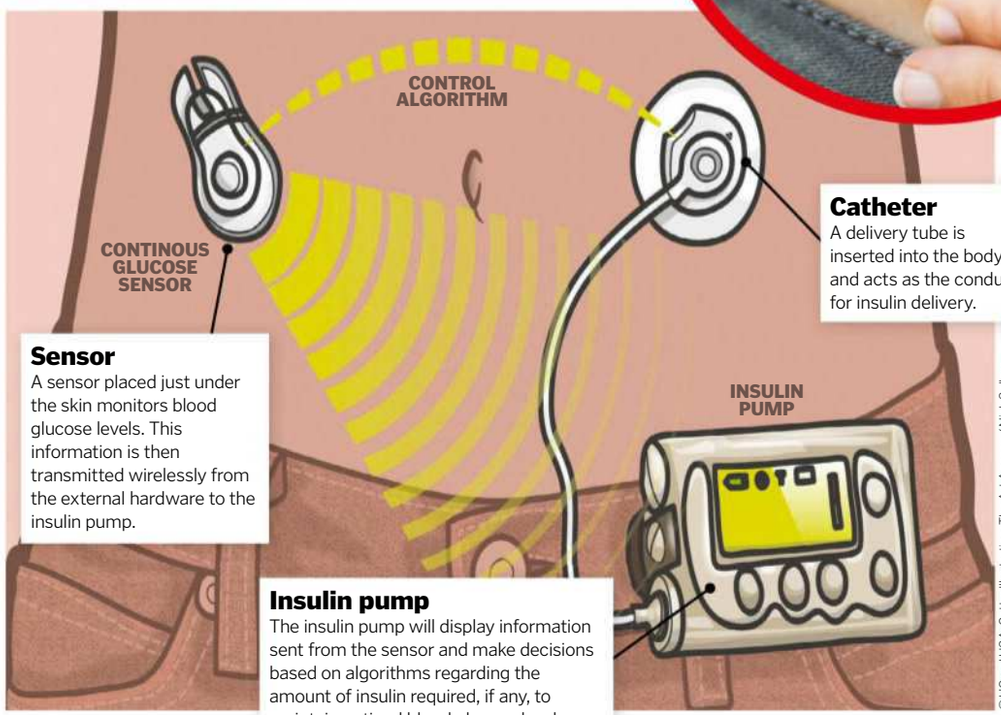
The artificial pancreas

This transformative technology can mimic the original organ

Around 400,000 people in the UK alone have Type 1 diabetes, a lifelong condition that requires constant monitoring and self-medication. Traditionally, sufferers have had to periodically prick their finger to measure their glucose levels with a glucometer, and then inject themselves with insulin to reduce their blood sugar levels. However, the artificial pancreas (AP) makes this continuous job of monitoring more manageable and less painful.

Sensors placed on the abdomen are wirelessly connected to an automated insulin pump. This sensor-pump relationship allows continual monitoring of blood glucose levels and automatically delivers the correct amount of hormones to balance these levels. This significantly reduces the possibility of human error when calculating insulin doses, and acts almost exactly like a real pancreas.

These innovative devices are currently being tested in trials to make sure they are safe and effective, but the results so far have been very promising indeed.



Catheter
A delivery tube is inserted into the body and acts as the conduit for insulin delivery.

Sensor
A sensor placed just under the skin monitors blood glucose levels. This information is then transmitted wirelessly from the external hardware to the insulin pump.

Insulin pump
The insulin pump will display information sent from the sensor and make decisions based on algorithms regarding the amount of insulin required, if any, to maintain optimal blood glucose levels.

The wearable UV sensor

L'Oréal have created a sensor to monitor UV exposure that can fit on your fingernail

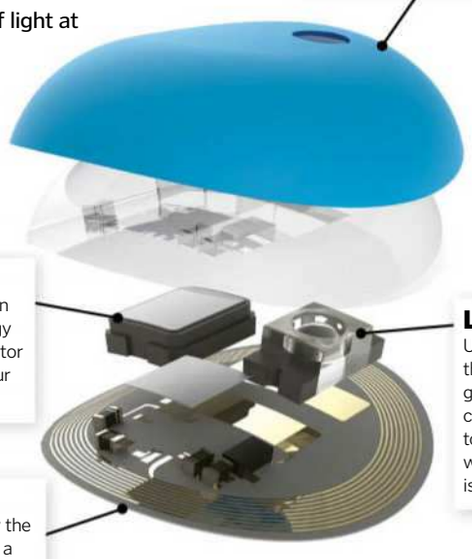
The UV Sense allows the wearer to monitor their daily sunlight exposure

Ultraviolet (UV) rays from the Sun are harmful to our skin and can cause skin cancer, sunburn and premature ageing. It's obvious that, when basking in the sunlight, protection against these invisible rays is vital. But UV exposure is a daily occurrence, not just when we're down at the beach.

In response to the need to keep an eye on our exposure to the Sun's rays, L'Oréal has developed the UV Sense, a device designed to monitor daily UV levels and inform the user when it's time to protect their skin. Fitting snugly on a fingernail, the UV Sense is a battery-free sensor that transmits surrounding UV levels to the accompanying app via near-field communication (NFC) technology. This will alert the user when they have exceeded their daily safe levels, and plots their exposure within the app. After all, you're worth it.

Exposing UV rays

Have the power to detect harmful levels of light at your fingertips



Protection
Less than 2mm thick, the UV Sense's waterproof capsule protects its tiny internal components.

Capacitor
Information based on the amount of energy stored by the capacitor is transmitted to your phone via NFC.

LED
UV light enters the device here, generating a current that flows to the capacitor, where the energy is stored.

Adhesive
Adhesive pads allow the UV Sense to stick to a fingernail for around two weeks before needing to be replaced.

HOLLYWOOD VS SPACE

What the silver screen has got right and wrong about the final frontier

Words by **Jonathan O'Callaghan**

THE MARTIAN

Author Andy Weir stated that his research for the science behind *The Martian* influenced some of the story's plot points

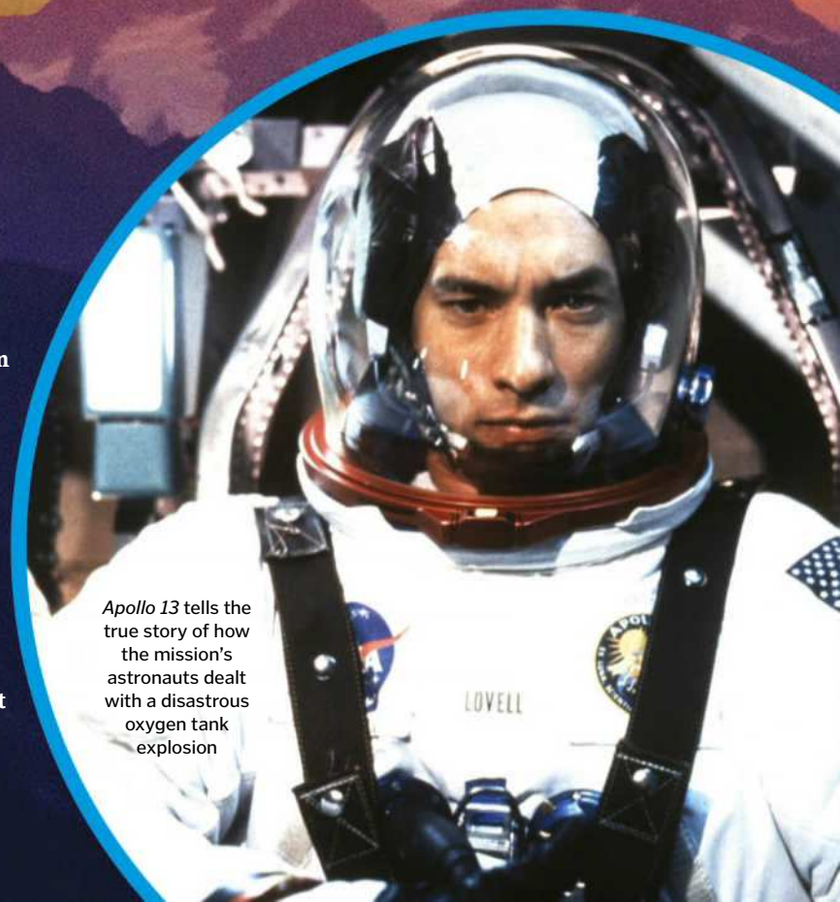
When Mark Watney (played by Matt Damon) becomes stranded on Mars, he must use his wits to survive in an extremely dangerous environment. The 2015 film is based on a book of the same name by author Andy Weir, who admitted he made one big concession to get the story rolling. The storm that strands Watney on Mars was depicted as having gale-force winds, but the thin atmosphere means that the winds would be almost negligible, so Watney probably would have been fine. Watney's movements on Mars also don't recreate how humans would really move on a planet with a third of Earth's gravity – he'd probably be hopping and shuffling around more than walking or running.

It did get a lot right though. For starters, the orbital dynamics of getting to Mars and back to Earth – complete with a risky slingshot manoeuvre – are spot on. As for using Martian soil to grow potatoes, this could also be possible, as scientists in Peru demonstrated in 2017. The movie also accurately depicted 'tornados' on Mars, which are very real and are known as dust devils. The idea of using inflatable habitats on the surface is also something NASA has been considering, although some have suggested they may need to be more rounded in shape to cope with the low pressure.

APOLLO 13

Apollo 13 is widely regarded as one of the great space films, retelling the dramatic story of the ill-fated NASA mission in both exciting and accurate fashion. But did it get everything right? Well, not quite. The film is praised for its depictions of all the equipment in the mission, from the spacecraft itself to the flight control room. Many of the characters in the film also bore a resemblance to their real-world counterparts. The actors even took a course in physics to ensure they were up to speed with the script.

There were a few minor errors though. Perhaps the most infamous is the use of the line, "Houston, we have a problem." That was never actually said during the mission, with the actual line from Jim Lovell (played by Tom Hanks) being, "Houston, we've had a problem." The far side of the Moon is also incorrectly called the dark side, with it not actually being in darkness during the mission. The film also made it look like NASA had to come up with a lot of things on the fly, when in fact they already had procedures for a lot of the problems they faced. Still, it didn't do a bad job compared to some other films.



Apollo 13 tells the true story of how the mission's astronauts dealt with a disastrous oxygen tank explosion

GRAVITY

In 2013's *Gravity*, our heroine Sandra Bullock must survive in Earth orbit when space junk goes haywire in a film that gets some key things right, notably on the technical side.

Its depictions of the International Space Station (ISS) and the Hubble Space Telescope are exquisite, as are its attention to detail on the spacesuits and spacecraft like the Soyuz capsule. The idea of space junk causing a chain-reaction effect like this in orbit is also very real, and it's called the Kessler syndrome. Some experts think that our debris in orbit could become so great that this becomes a near certainty in the future.

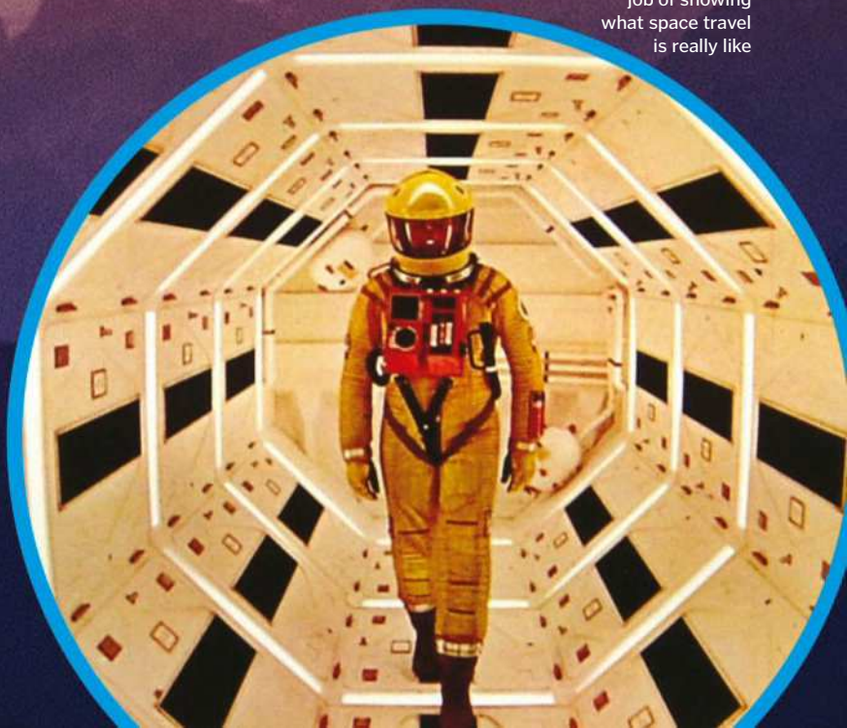
However, the film gets a lot wrong, most notably that the protagonists are able to travel between Hubble, the ISS and the Chinese Tiangong-1 space station with ease. In reality there's no feasible way to get between these locations in orbit as they're separated by vast distances. What's more, the film suggests a Kessler syndrome in low Earth orbit (LEO) would knock out communications satellites, but LEO is just a few hundred kilometres up, whereas communications satellites orbit at altitudes of around 35,000 kilometres above Earth.

"The idea of space junk causing a chain-reaction is very real"

The ISS looked great in Alfonso Cuarón's *Gravity*, but the science was not spot on

2001: A SPACE ODYSSEY

Stanley Kubrick's 1968 film is highly regarded, and for good reason. The film did a wonderful job of depicting space travel, from the slow, silent and somewhat monotonous journeys to simple things like the communications delay back home. Its depiction of an orbiting space hotel wasn't bad at all either, with a large rotating structure being used to simulate gravity. It even predicted the arrival of the Space Shuttle, although we haven't quite reached the Pan Am heights touted by Kubrick – yet. As for Hal, you've only got to talk to your Alexa or Google Home personal assistant to see how rapidly technology is catching up to this vision of the future, although hopefully without all the killing and whatnot.



2001 did a good job of showing what space travel is really like

INTERSTELLAR

All you need is love. At least, that's what Christopher Nolan would have us believe in his 2014 film *Interstellar*. Sure, the film looked great, but did it get everything right? A bit.

First up, the centrepiece of the film: the black hole. It's well documented that the team got theoretical physicist Kip Thorne (2017 Physics Nobel Prize laureate) onboard to model the black hole, which actually spawned a couple of papers. How it looked, with the light bending around it, was probably quite accurate based on what we know. As for falling into it, well, whether a person could survive the stretching of space and time – known as spaghettification – is up for debate. Planets orbiting a black hole also seems feasible, although it's questionable if they could be habitable.

As for the interstellar travel itself, the idea of wormholes is not beyond the realms of fantasy, although they do remain purely theoretical. The spacecraft itself seemed mostly fine, except for the fact it needed a rocket to escape Earth's gravity but could escape the intense gravity of a 'black hole planet' with no rocket required. As for the theory of time dilation – that the astronauts would age slower than us on Earth – well, this is fairly well established and enshrined in the known laws of physics thanks to Einstein. Not bad, Nolan.

> **"Whether a person could survive spaghettification is up for debate"**

The depiction of *Interstellar*'s black hole, Gargantua, was praised for its scientific accuracy

ARMAGEDDON

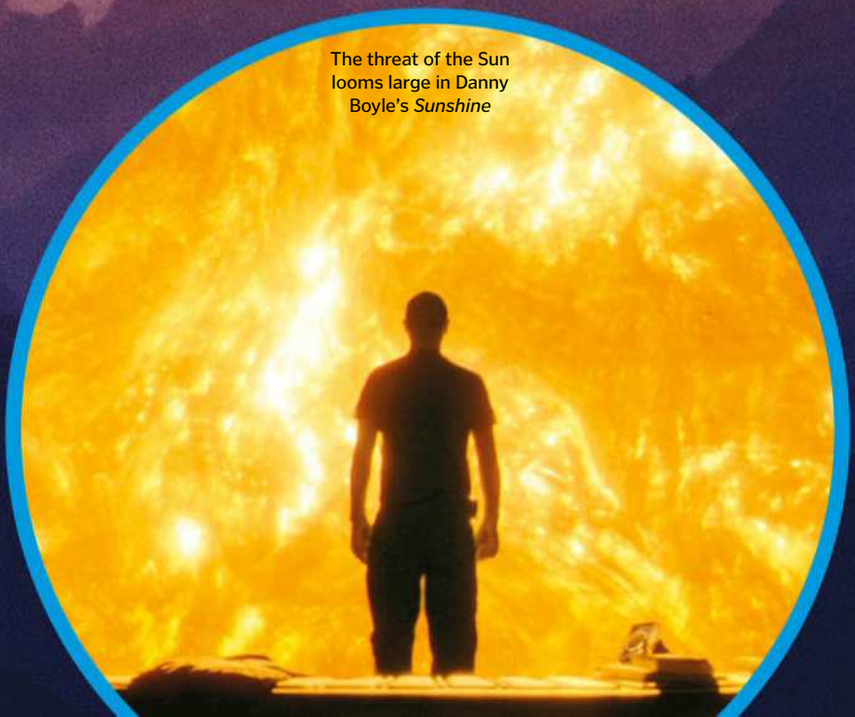
Where to start, as 1998's *Armageddon* gets so much wrong it is almost unbelievable, with an estimated 168 inaccuracies in its 150 minutes. One of the biggest is the size of the asteroid itself, said to be as large as Texas. How would no one spot that approaching Earth? Then we have the attempt to blow up the asteroid using nukes, which simply wouldn't have worked. You'd be much better off trying to move it way in advance with a small nudge. Even if they did blow up the asteroid, those pieces wouldn't go anywhere – they'd still rain down on Earth and cause untold damage. The approach to space exploration in this film is also terrible, with space shuttles flying around like planes. If we were giving ratings for scientific accuracy, this film would get a Texas-sized zero.

"Armageddon gets so much wrong it is almost unbelievable"

Highly questionable science didn't stop *Armageddon* grossing $553 million at the box office

SUNSHINE

The premise of this 2007 film might seem absurd: our Sun is dying, and life on Earth is doomed unless we can restart it. However, it's kind of based on theory, with the film's scientific advisor – a little-known chap back then called Dr Brian Cox – saying they imagined a theoretical particle called a Q-ball that could stop the Sun's core. While it's a bit far-fetched, it's very slightly possible. What's less likely, however, is the plan to restart the Sun by sending a huge nuclear bomb inside it to get its core up and running again. The bomb itself would have melted long before it reached the Sun, and even if it survived, the Sun is huge; we simply couldn't restart it with a bomb. Also, why send humans on this mission at all? It certainly seemed a bit unnecessary as it could have been controlled remotely.



The threat of the Sun looms large in Danny Boyle's *Sunshine*

Bruce Willis makes a decent action hero, but he might want to brush up on his science

LIFE

In 2017's *Life*, our heroes must deal with a mysterious Martian organism gone rogue as it wreaks havoc on the ISS. The idea of a sample return mission to Mars as depicted in the film is sort of accurate, and NASA is currently looking at undertaking such a mission in the near future, although the organism would probably be brought back to Earth, not to the ISS. One of the big things it gets wrong, though, is how NASA tries to push the ISS into deep space later in the film. While we do use docked capsules to push the station, you couldn't push it that far, and it probably wouldn't end up re-entering our atmosphere either.

Jake Gyllenhaal and crew try to contain a deadly alien threat in Daniel Espinosa's thriller *Life*

Star Trek vs Star Wars

***Star Trek* is famous for a whole host of technologies, from the transporter to the warp drive. The former is a neat way to get people to the surface of a planet quickly without needing a scene where they fly to the surface, but at the moment transporting matter doesn't look too feasible. Warp travel, or faster-than-light travel, also remains a theoretical concept and one that many don't think will ever be possible. The medical tricorders, though, are something scientists are developing right now – well, at least devices to diagnose people with certain conditions quite quickly.**

As for *Star Wars*, things get a bit more fanciful. You're probably not going to be wielding a lightsaber or using the force any time soon, but you might well have a robotic companion like a droid one day given our advancements in artificial intelligence and robotics. It also did a pretty neat job of predicting some of the habitable worlds we are finding outside our Solar System, from strange gas giants to water worlds.

It's a battle as old as time, but which film comes out on top with science?

Face In Space

Discover how this innovative company prepare and launch customers' payloads into the stratosphere

There's never been more global media interest in space, especially with SpaceX's spectacular Falcon Heavy test launch and astronauts aboard the International Space Station sharing their out-of-this-world experiences and research via social media.

Face In Space is a company based in Bristol, UK, that was born out of a passion for experimentation in the field of aerospace and defence engineering. Since 2008 they have launched over 40 exciting projects into space.

Using high-altitude weather balloons, Face In Space launch pictures or small items mounted on a boom below into 'near space' (around 30 kilometres above Earth) and film them on high-definition cameras. The end results are stunning pictures, with the blackness of space creating an impressive backdrop against Earth's blue atmosphere.

A wide range of items have been sent up to date, from a competition winner's picture for the Heart Radio breakfast show, to a wedding proposal, which consisted of a teddy bear holding a wedding ring and a message saying 'Marry me, Judith!' Luckily, she said yes!

For more information, visit **www.faceinspace.co.uk** or find them on Facebook and Twitter. Or you can contact the team directly at **info@faceinspace.co.uk**.

Stratospheric launches step-by-step

As you can imagine, there's rather a lot to plan before launching a weather balloon towards space

1 Planning

Legal flight permits, jetstream winds and extreme temperatures of -50 degree Celsius are just some of the many factors to consider before you even get around to running flight path predictions to give an approximate landing place. For that reason, the company have a hefty public liability insurance policy!

2 Apply for a CAA permit

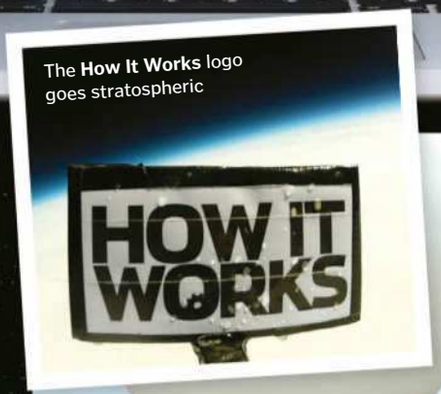
One of the most important steps is submitting a request for a flight permit (called a Notice to Airmen, or NOTAM for short) to the Civil Aviation Authority (CAA) at least a month in advance. This warns aircraft of a potential hazard for a brief time frame. In the request you will need to enter information such as your name, address and contact phone number (as pilots may need to speak to you on the day), as well as the launch site location, planned date and time.

3 Order parts & build the payload

The box suspended below the balloon is called the payload. This can simply be an insulated box approximately the size of a shoebox that primarily contains the tracking and camera equipment. For the launch, there are three key components that must be considered: the helium-filled balloon, a recovery parachute and the payload. When building it's important to ensure that everything is secure and weatherproofed.

4 Flight path and landing zone prediction

As the balloon goes very high, the distance it can travel during a typical flight (often three to four hours) can vary dramatically depending on the weather. Therefore it is important to analyse the weather leading up to launch day and run a flight path predictor. There is a wealth of resources at **www.habhub.org**, including a useful landing predictor, which is like a Google Maps for launching weather balloons. Simply put the day, time and launch site location into the tool and it will show a plot of where the balloon is likely to burst in the atmosphere before riding down on its parachute. On a sunny day with low winds the payload may land just an hour's drive away, but on a very windy day it may land in the North Sea or even Norway!



5 Pre-launch tests

Before launch, make sure all the electrical equipment is fully charged, the memory cards are erased and the GPS trackers are tested. It would be frustrating to have an expensive, fully inflated balloon and no way of tracking it due to dead batteries!

6 The launch

It is often preferable to launch at dawn, so everything will need to be packed and ready the night before, including the helium gas canisters, balloon rig, balloons and so on. Filling the helium balloon is the most focused and stressful part of the day. When you finally let go of the payload and it soars skywards, it is both an exhilarating and apprehensive time – it is literally out of your hands for the next couple of hours.

7 Landing & collection

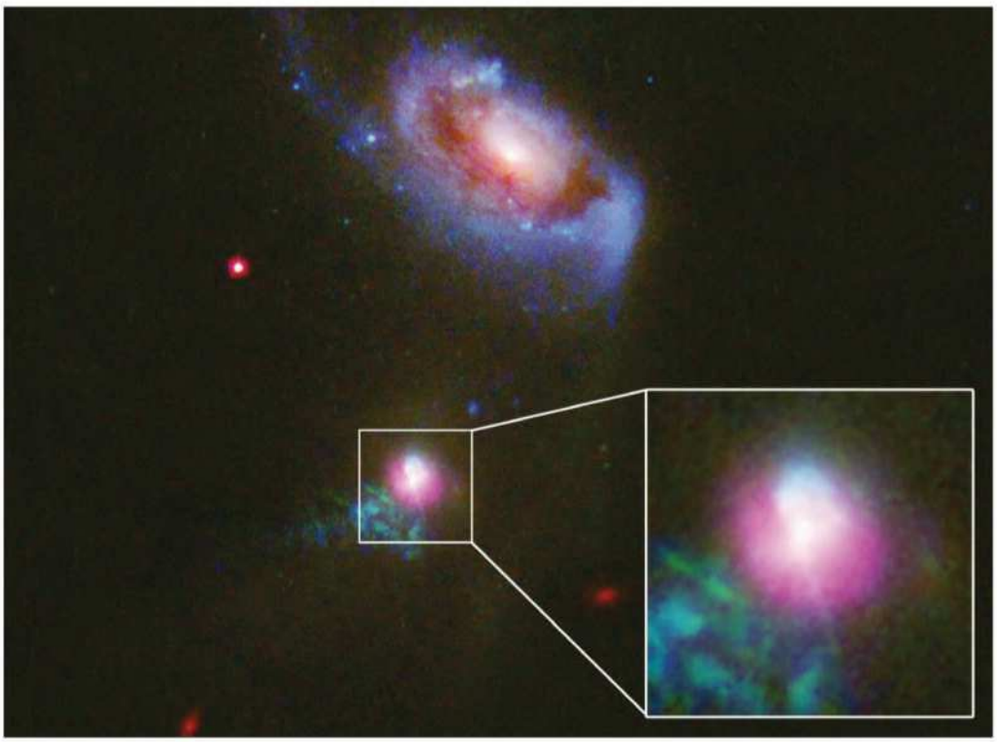
Normally, after watching the balloon ascend for about 15 minutes, the team pack up and then drive in the direction of the expected landing zone location. Once the payload has been recovered there is a quick review of the camera's flight footage before it is then backed up. When the team return to base they can send a selection of video stills to the eager customer before the full video is released.

FACE IN SPACE™

If you're interested in launching a project, contact the Face In Space team at **info@faceinspace.co.uk** – they will be happy to discuss any project and budget

Burping black holes

This is what happens when a black holes turns off and on again



The burping galaxy (bottom) and its companion (top) are seen here in X-ray and optical light

In 2018, astronomers revealed something rather unusual: a few years earlier they'd seen a supermassive black hole appear to 'burp' twice. Called SSDS J1354+1327, the galaxy containing the black hole is located about 800 million lightyears from Earth, and on two occasions, 100,000 years apart, it expelled bursts of high-energy particles in the form of bright light. The astronomers didn't see the burps in action, but they did see two emissions on either side of the galaxy that appeared to be the remnants of them. They're thought to have happened about 1 million years ago. But why?

Well, the answer comes from a nearby companion galaxy. It looks like the two galaxies collided in the past, and they're still linked by streams of stars and gas. So the black hole ate material from the companion galaxy on two separate occasions, namely extremely hot gas, and in the process flared up and released particles. And it's not alone either, as other black holes have been known to belch too, even our own Milky Way. The universe is a gassy place, after all.

A comet's close call

A dramatic event in 1883 could have been the end of life on Earth

Did Earth narrowly avoid an extinction event back in the 19th century?

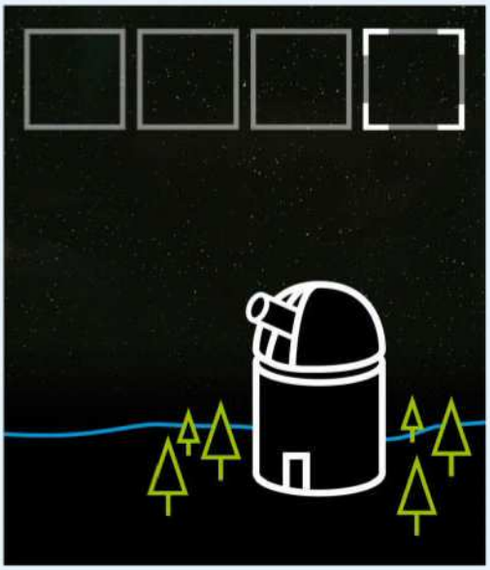
Asteroids and comets fly past Earth pretty regularly, and despite some alarming headlines, we're normally okay. However, back in 1883 it seems that we actually came extremely close to an impact that could have rivalled the one that wiped out the dinosaurs some 66 million years ago.

Back then, a Mexican astronomer called José Bonilla noticed a hazy mist over the Sun of unknown origin, spotting 447 fragments in total. While he didn't know what they were, a French astronomy journal suggested they were simply high-flying birds or bugs. But in 2011 a re-examination of Bonilla's observations suggested he may have seen a comet breaking apart in our atmosphere, just 8,000 kilometres above the surface.

Without any other observations at the time it's difficult to know for sure if this was the case. If it was a comet, however, it's possible that each of those fragments could have been big enough to level a city. Had such a comet or its fragments hit our planet, things could have been pretty dire. Thankfully, we're still here to tell the tale.

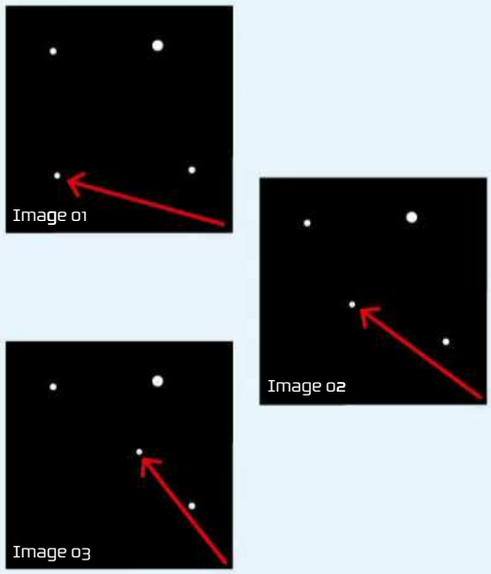
Spotting near-Earth asteroids

Could you be the one who discovers the next asteroid making its way towards Earth?



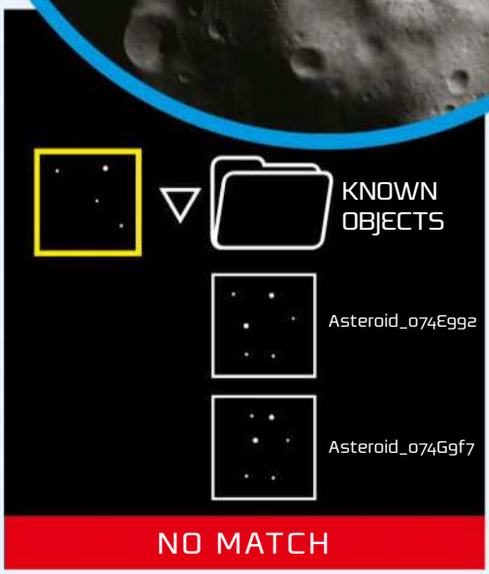
1 Searching the skies

The night sky is already abundant with faint specks of light, but somewhere among them is a near-Earth object yet to be found. Only by taking multiple exposures of the night sky will you be able to find one.



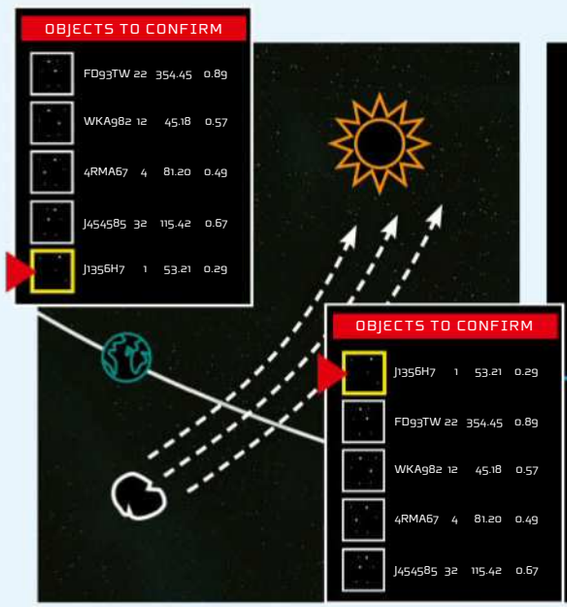
2 Distinguishing asteroids

If you notice a speck of light moving fast relative to the background stars, this is the strongest evidence that an asteroid has made its way across your field of view.



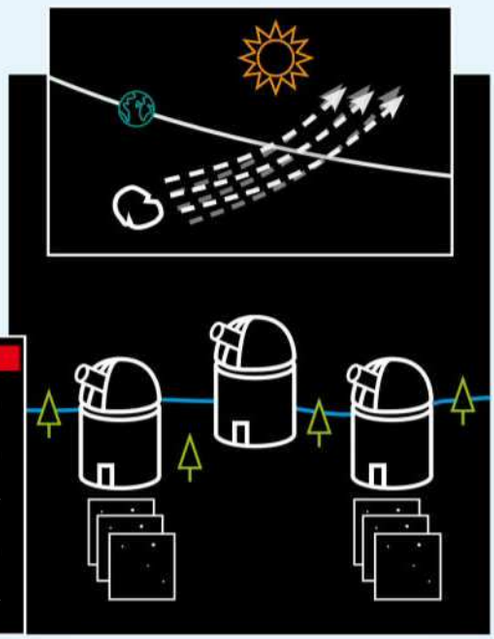
3 Has it already been discovered?

NASA and other institutions have extensive databases of known near-Earth asteroids. A search of these databases will show if this asteroid has already been discovered. If not, this asteroid will be added to a list of objects waiting to be confirmed.



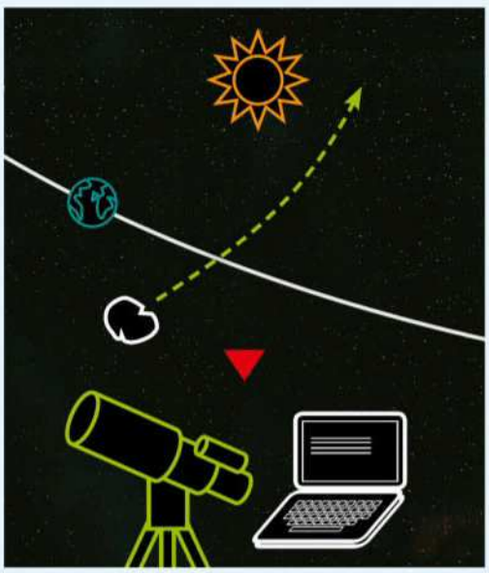
4 Calculating its trajectory

Whether an object is passing close to Earth can be calculated by refining its trajectory. If it is then it will be made a high priority, warranting a quicker follow-up period.



5 Calling all astronomers!

Follow-up observations are made by astronomers worldwide. Whether it be amateur astronomers or big institutions like NASA, every piece of data collected about an asteroid is important for defining its orbital path.



6 Clarify and collect data

All this data allows NASA's Planetary Defense Office to definitively calculate the true trajectory of a near-Earth asteroid. This determines whether it's likely to hit Earth or whether it will pass us by.

A ferry carrying immigrants docks at Ellis Island, circa 1902-1913

Passengers are inspected by medics on deck upon arrival in 1900

JOURNEY TO AMERICA

During the 19th century millions travelled to seek freedom and fortune in the US

Words by **Tim Williamson**

America, as former President John F Kennedy pointed out, is a nation of immigrants. Today, an overwhelming majority of Americans, from Donald Trump to Kim Kardashian, can find immigrant blood not too far back in their family tree. Some of these ancestors arrived seeking to make their fortune in business or trade, or to find a better quality of life. However, others made the long journey to escape persecution, poverty and even genocide in their land of birth. Towards the end of the 19th century, both these factors led to a huge rise in immigration to the US.

150 years ago there seemed no better prospect than the opportunities and freedoms available in America. After the end of the Civil War in 1865 the country underwent massive restoration, continuing its industrialisation and expansion to the west. Before long it was already surpassing the UK as the world's leading industrial power. The bustling factories and busy dockyards in cities such as New York, Baltimore, Boston and Philadelphia were huge draws for migrants seeking work.

These cities became key destinations for the major transatlantic ferry routes, which in the new age of steam were transporting more people across the ocean, and quicker than ever before. Records for the fastest crossing were smashed almost every year, and rival shipping companies were in constant competition to build the fastest ships. This meant passengers travelling from Italy, Ireland, Germany, the UK and elsewhere could make the journey across the Atlantic in a few days rather than the previously gruelling ordeal of a few weeks by sail. This fierce competition sometimes resulted in tragedy, such as the sinking of RMS Titanic in 1912.

Catastrophic accidents aside, travelling aboard the liners was a pleasant cruise for first- and second-class passengers, while life for the majority in third class, or steerage, was far less pleasant. These were the cheapest tickets and afforded only cramped living space, with little or no access to the open air on deck. Almost all steerage passengers were migrants from among the poorest of society, and the deck would be filled with accents spanning from the Mediterranean to the Baltic Sea.

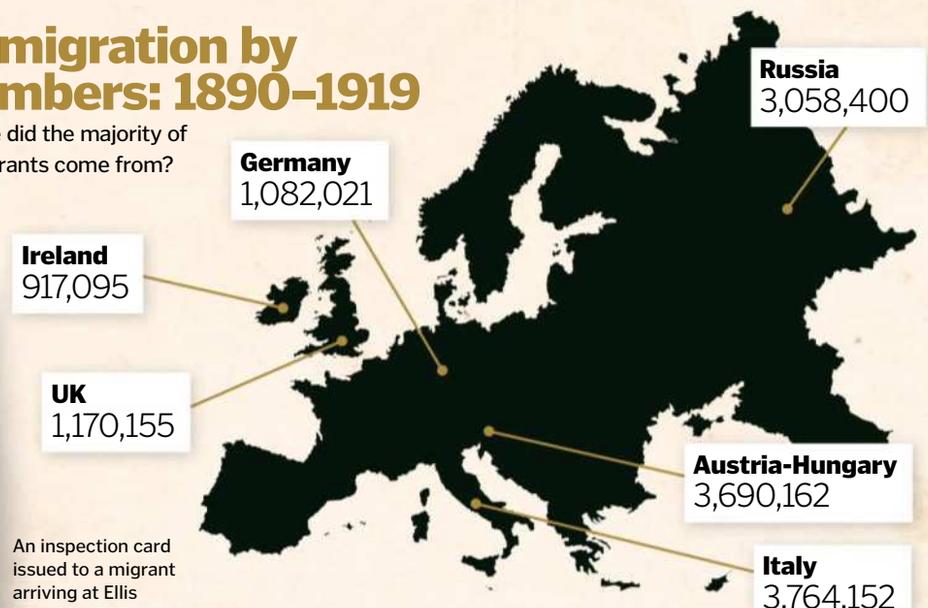
Regardless of what they had left behind, for most immigrants the first sight of their new home was the Statue of Liberty in New York Harbor, at the time a shimmering light brown colour rather than the green we see today. A plaque on the base of the monument reads, "Give us your tired, your poor, your huddled masses yearning to breathe free". It was a welcome to the New World to those travelling from the old.

The largest group to enter the US between 1880–1920 were Italians. Approximately 4 million arrived during this period, a large proportion of whom were men seeking work either in order to settle or to send money back home. In fact, many of those arriving in the US did not look to stay permanently, but hoped to earn a decent wage and then return home. Millions of lira (the old Italian currency) were sent back to the old country by those working in the US, helping to support their families.

At the beginning of the 20th century there were already large Italian-American communities in major US cities, making it easier

Immigration by numbers: 1890–1919

Where did the majority of immigrants come from?



An inspection card issued to a migrant arriving at Ellis Island in 1925

for new immigrants to settle. In 1900, New York's Italian population numbered 225,000 – a small but significant minority in a city of 3.4 million. New arrivals would commonly know family members or friends already living within these communities who could assist with finding work and a place to stay.

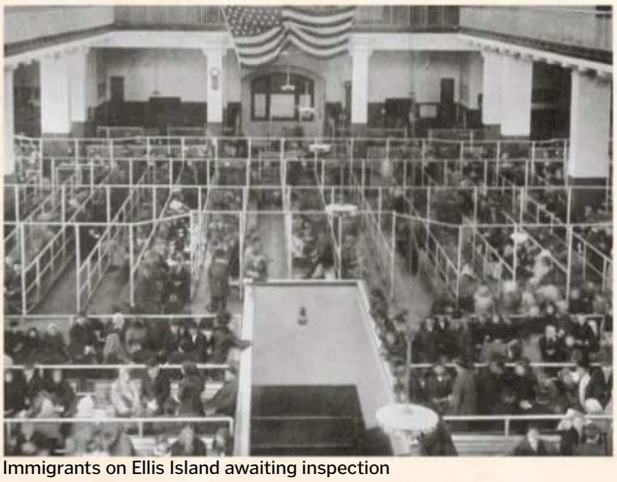
Other nationalities and groups were not as well established in the US during this period. From the 1880s, Jews living in the Russian Empire faced increased discrimination and were targeted with violence and oppressive laws. Although Jews made up only five per cent of the Russian population at the time, they accounted for 50 per cent of the country's immigrants to the US. Many of them arrived with experience as merchants, tailors and peddlers, bringing with them a range of skills.

America's large cities were already home to large Jewish communities of several nationalities, and the new arrivals from Eastern Europe were able to easily settle in these neighbourhoods, particularly in New York's 'Little Germany' in Lower Manhattan. This nickname was rather misleading, as the area was also home to many Lithuanians, Poles, Ukrainians, Austrians and others. Here, successful second-generation Jewish families were gradually moving out to the expanding suburbs at the city limits, leaving room for others to settle and find their piece of the American Dream.

However, not all Americans were welcoming to what became known as the 'new immigrants', as opposed to first-, second- or even third-generation immigrants from previous decades. In 1892, Ellis Island opened in New York Harbor as the new official facility through which immigrants entering New York would be processed and assessed.

The rules governing those who would and would not be permitted entry became stricter as time went by, with subsequent laws piling on to stop would-be citizens. At first, only those with infectious diseases were sent home or quarantined, then known criminals, then anyone deemed to be 'mentally deficient' or 'feeble-minded'. People were put through often humiliating medical and mental tests to determine whether they were likely to become a burden on society, but relatively few were actually deported as a result.

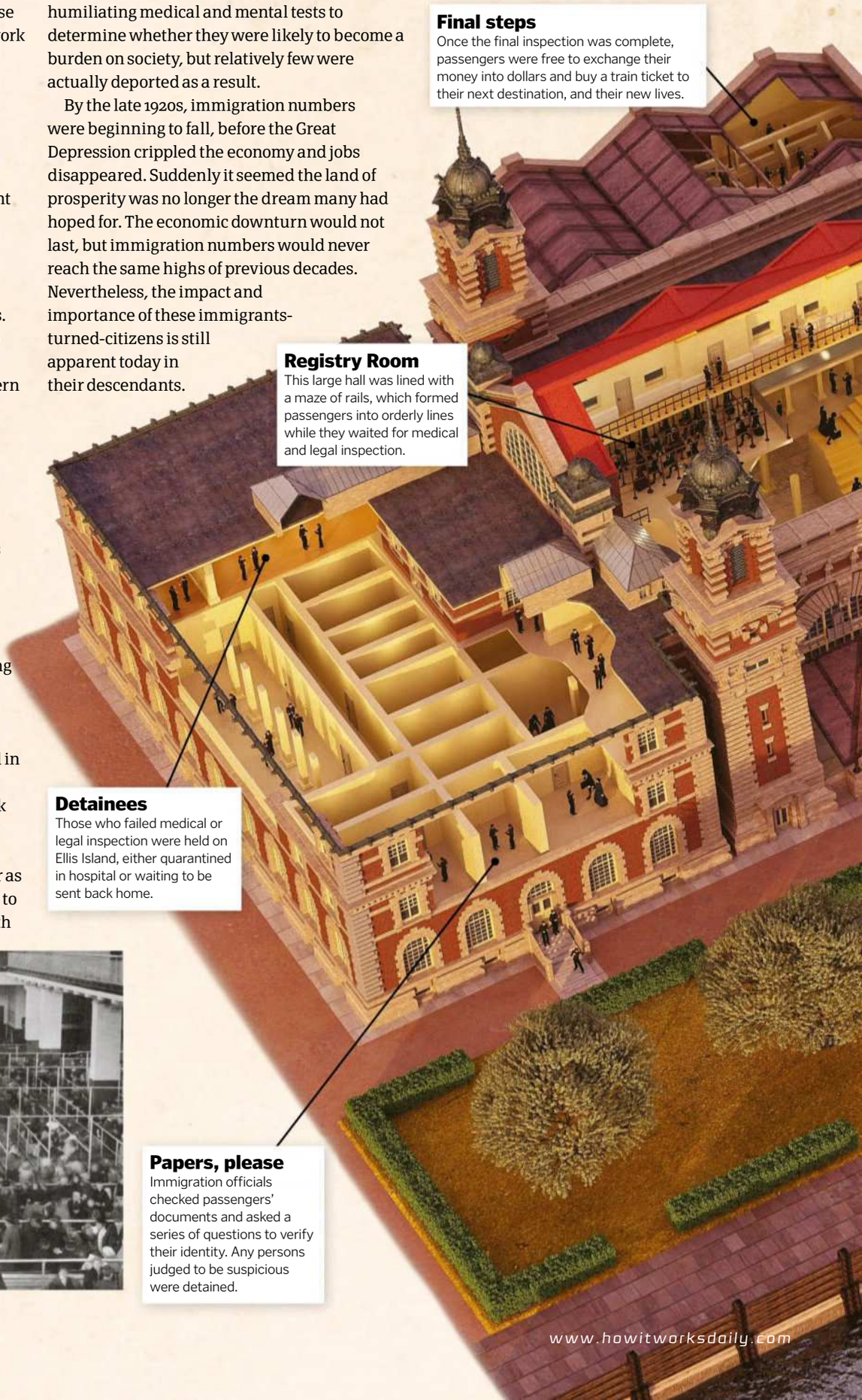
By the late 1920s, immigration numbers were beginning to fall, before the Great Depression crippled the economy and jobs disappeared. Suddenly it seemed the land of prosperity was no longer the dream many had hoped for. The economic downturn would not last, but immigration numbers would never reach the same highs of previous decades. Nevertheless, the impact and importance of these immigrants-turned-citizens is still apparent today in their descendants.



Immigrants on Ellis Island awaiting inspection

Ellis Island

For over 12 million people, this facility was the gateway to the US



Final steps
Once the final inspection was complete, passengers were free to exchange their money into dollars and buy a train ticket to their next destination, and their new lives.

Registry Room
This large hall was lined with a maze of rails, which formed passengers into orderly lines while they waited for medical and legal inspection.

Detainees
Those who failed medical or legal inspection were held on Ellis Island, either quarantined in hospital or waiting to be sent back home.

Papers, please
Immigration officials checked passengers' documents and asked a series of questions to verify their identity. Any persons judged to be suspicious were detained.

Close observation
The huge numbers of people waiting for inspection meant queues often lasted several hours. Doctors and officials would watch the crowd for further signs of sickness and disease.

Doctor appointment
A final, very brief medical inspection was carried out to identify physical or mental ailments. Those who failed the examination were marked with chalk and detained.

Tagging and bagging
After leaving the boat, each passenger was handed a numbered tag and ushered into the baggage hall, where they would wait in line for further inspection.

On the boat
After arrival in New York Harbor, health inspectors boarded to check for infectious disease among all passengers. Third-class, or 'steerage' ticket holders were then moved for processing on Ellis Island.

The Chinese Exclusion Act

During the 19th century, thousands of Chinese prospectors crossed the Pacific to join the great American Gold Rush that had gripped the world. Later, in the 1860s, thousands more followed to work as labourers, constructing the transcontinental railroad. However, the presence of this Chinese population, although relatively small and centred in San Francisco, California, quickly became a political issue for the entire nation.

In 1882, Congress passed legislation to block all Chinese immigration into the US. This was the first such law that excluded immigration based on nationality or race. Supporters of the Act argued that cheap Chinese labour threatened the American working class – this despite the fact they actually made up a small fraction of the population. Debate surrounding the Act was also laced with racist and xenophobic language. It would not be repealed until 1943, by which time America and China were allies in World War II.

The Chinese Exclusion Act also affected immigrants already living in the US – those who left the country for any reason had to officially apply to reenter

The NHS through the decades

Discover just some of the many medical milestones throughout 70 years of the UK's National Health Service

5 July 1948

Birth of the NHS

Launched by the health secretary Aneurin Bevan (second left), the NHS would act as an umbrella organisation and unite medical professionals from different disciplines under a service that would be free for all at the point of delivery. The NHS's first patient was 13-year-old Sylvia Beckingham (left) at Park Hospital in Machester (now Trafford General Hospital).

1958

Polio and diphtheria vaccinations rolled out

Cases of polio and diphtheria had reached epidemic proportions, with up to 70,000 cases of diphtheria reported. The NHS rolled out a vaccine to everyone under the age of 15, drastically reducing the prevalence of both diseases.

1960

First UK kidney transplant

1962

The first full hip replacement

At Wrightington Hospital, near Wigan, Professor John Charnley performed the first full hip replacement. In order to continually develop the design, patients agreed to have the artificial hip removed post-mortem for analysis, and in 1962 the modified 'Charnley hip' was realised.

2012

First UK hand transplant

2007

Rise of the robot surgeon

Doctors at St Mary's Hospital, London, began working with a revolutionary robotic arm to perform cardiac operations. The da Vinci robot was used to deliver electric currents to specific parts of the heart without the need for traditional invasive and risky surgery.

2002

First gene therapy success

Gene therapy is a process whereby genes are used to treat conditions by replacing or introducing new genes to a patient. This method successfully treated 18-month-old Rhys Evans at Great Ormond Street Hospital, London, who suffered from severe combined immunodeficiency disease at the time.

2018

Today's technology

The NHS continues to evolve, using advanced devices and innovative treatments to help patients recover

Magnetic resonance imaging

An integral piece of equipment in the field of neurology, MRI scanners use a magnetic field and radio waves to form images of the brain and almost any other body part of the body.

Da Vinci Surgical System

The da Vinci system enables surgeons to perform robot-assisted operations to treat a variety of conditions. Poole Hospital in Dorset was the first hospital in the UK to use the robot to treat cancers.

May 1968

First UK heart transplant

October 1968

Sextuplets are delivered after fertility treatment

After a fertility treatment called gonadotrophin, Sheila Thorns gave birth to six babies by caesarean section. 28 medical staff attended the delivery at Birmingham Maternity Hospital, but unfortunately – despite the doctors' best efforts – three of the babies did not survive.

1972

CT scanners are introduced

Created by British engineer Sir Godfrey Newbold Hounsfield, the computerised tomography (CT) scanner could produce three-dimensional images of internal organs like the brain, for example, with the use of two-dimensional X-rays.

1978

World's first baby born using IVF

A new technique developed by gynaecologist Dr Patrick Steptoe and physiologist Dr Robert Edwards resulted in the birth of Louise Brown, the first baby born by in vitro fertilisation (IVF).

1988

Breast screening introduced

The NHS launched a project to tackle deaths caused by breast cancer across the nation. Women over the age of 50 were offered free mammograms, a process that uses X-rays to detect tissue abnormalities within the breast.

Prescription dispensing robot

The days of organising and collecting prescription medication by hand could soon be over. Poole Hospital has the first UK dispensing robot, which can deliver medicines around the hospital.

Linear Accelerator

These machines, along with Image-Guided Radiotherapy (IGRT), pinpoint the position of tumours, allowing for more accurate and faster treatment.

Q&A Geoffrey Walker OBE

With 33 years' experience working in the NHS, Geoffrey has seen first-hand the monumental changes to our hospitals

How do NHS hospitals compare from the beginning of your career to today?

I could liken it to the fact you could smoke on the wards back then, and now you have iPads. The biggest fundamental change for me, without a doubt, is technology. When I started on the wards in 1983 everything was on paper, there were absolutely no computers. So if you needed to get any information about a patient you had to wait until the paper copy was sent to you from the laboratory. When we talk about the NHS in the 21st century, it's very different – the technology that has now become a part of my job – so it is unrecognisable to back then.

What has been one of the major changes you have seen in NHS hospitals?

When you went to see a patient you would take their temperature, pulse, blood pressure, and all of that would be written on the chart at the foot of their bed. Now we have Vital PAC, which is a hand-held device that the nurses can carry and enter all their observations. It can alert you, for example, that Mr X's observations are due or that his blood pressure is above what it should be. Sitting in my office, I can check on any patient, on any ward, anywhere in the hospital and see how they are doing.

Have technological advancements sped up the process of patient treatment?

Absolutely! What you want to do is spend more time with the patients and less time writing. Take the insertion of a central line [a central venous catheter], for example. You used to insert a central line and send a patient away for an X-ray to see if it was in the right position. Now we can use an electrocardiogram (ECG) and know instantly if it's in the right position without having to do an X-ray. A nurse can do that at the bedside with a local anaesthetic in under an hour, and the risks are minimised. Technology minimises risk, improves access and enhances care.

What do you hope to see moving into the next 70 years of the NHS?

It doesn't matter what technology we have or what information we are given, the most important person is the patient. Florence Nightingale addressed in her notes on nursing that the first requirement of a hospital is that it should do the patient no harm, and this remains as important today as it did in 1859. We need technology and more importantly so does the patient – I see it going from strength to strength.

Impossible bottles

The truth behind this intriguing art form

A type of puzzle, impossible bottles contain an object that appears far too big to fit inside. The bottle is never cut, so the trick is to choose an object that expands naturally. One common method involves placing the bottle over a branch bearing unripe fruit and allowing it to grow.

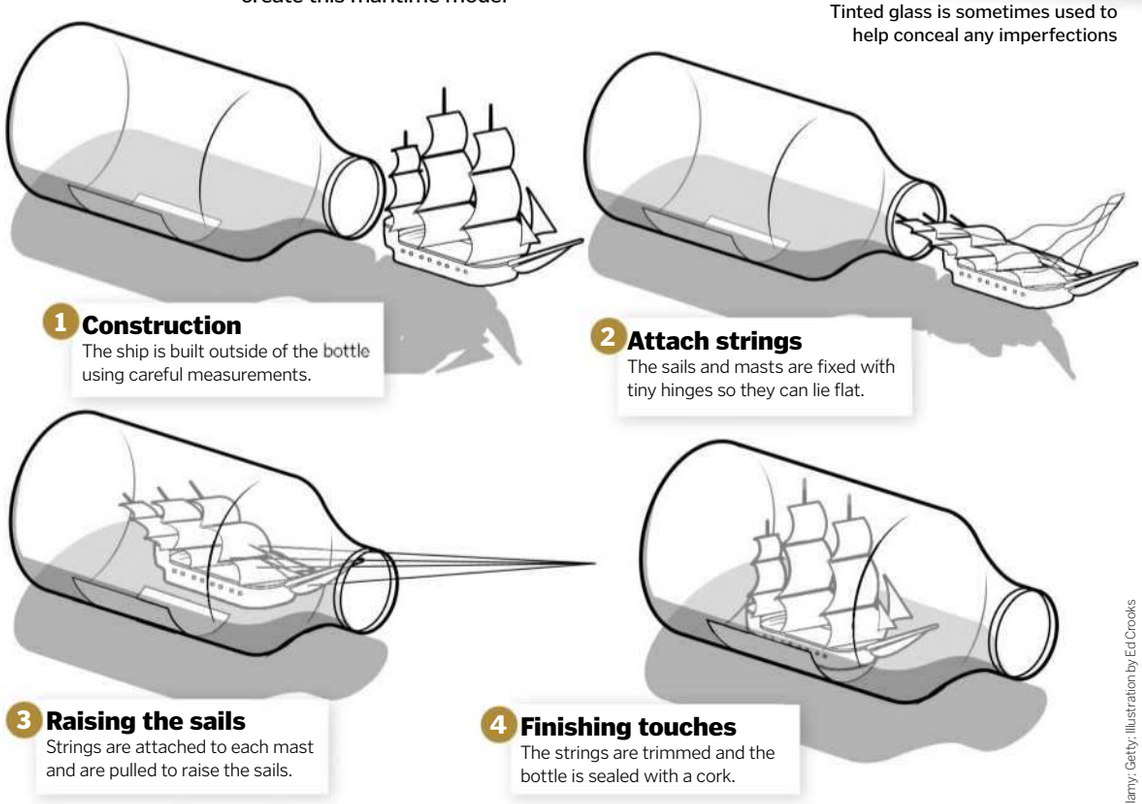
A ship in a bottle is another famous head-scratcher, one that involves a more complex process but requires just as much patience. This maritime craft, which dates from the late-19th century, uses a 'flat-pack' method.

However, impossible bottles appear to go back even earlier to the mid-18th century. Many early examples contain biblical scenes and are believed to have originated from monasteries.

Building a ship in a bottle

It takes patience and skill to create this maritime model

Tinted glass is sometimes used to help conceal any imperfections



1 Construction
The ship is built outside of the bottle using careful measurements.

2 Attach strings
The sails and masts are fixed with tiny hinges so they can lie flat.

3 Raising the sails
Strings are attached to each mast and are pulled to raise the sails.

4 Finishing touches
The strings are trimmed and the bottle is sealed with a cork.

Cockney rhyming slang

Have a butcher's (look) at the brass tacks (facts) behind London's secret language

Playful and inventive, Cockney rhyming slang is a way of speaking that originated in the East End of London. It's believed to have evolved during the first half of the 19th century as a secret code among criminals designed to bamboozle the police before being adopted by costermongers (street traders).

Rhyming slang replaces a subject with two or three words, the last of which rhymes with the subject. Usually, the rhyming word is dropped in conversation, helping to conceal the true meaning of the sentence. For example, stairs rhymes with 'apples and pears', which is shortened to 'apples'.

The original inspiration for these phrases varied wildly, from London locations to literature and music hall performers. However, some constructions relied on the Cockney accent to rhyme, such as 'Joanna' for 'piano' (pronounced 'pianna').

Cockney rhyming slang spread beyond the East End when television and film helped to popularise the secret lingo throughout the country. It's ever-evolving, and more recent slang includes the names of various celebrities and politicians.

WORD	ORIGINAL SLANG	SHORT FORM
LOOK	BUTCHER'S HOOK	BUTCHER'S
TALK	RABBIT AND PORK	RABBIT
PHONE	DOG AND BONE	DOG
LIE	PORKY-PIE	PORKY
HAIR	BARNET FAIR	BARNET
MATE	CHINA PLATE	CHINA
HEAD	LOAF OF BREAD	LOAF
TEETH	HAMPSTEAD HEATH	HAMPSTEADS

TV shows such as *Steptoe and Son* (circa 1960s) brought rhyming slang into the mainstream

Left: some common Cockney terms. Dropping the rhyming word with the short form helped hide the true meaning of a phrase

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Sir Harold Gillies is considered the father of plastic surgery

The Queen's Hospital in Sidcup, UK, (now the Queen Mary's Hospital) focused on rehabilitation as well as treatment for plastic surgery patients

Gillies treated soldiers who had suffered horrific facial injuries, his reconstructions helping them look more like their old selves

A life's work

A fantastic life in plastics

1882
Harold Gillies is born on 17 June in Dunedin, New Zealand, but later moves to the UK to study medicine at Cambridge University.

1915
With WWI raging, Gillies joins the Royal Army Medical Corps and is posted to France.

1916
Gillies opens a plastic surgery unit at the Cambridge Military Hospital in Aldershot to treat wounded soldiers.

1917
Opens Queen Mary's Hospital in Sidcup, Kent, where he and his colleagues perform more than 11,000 operations.

Sir Harold Gillies

A plastic surgery pioneer who rebuilt the faces of thousands

Many soldiers who fought in WWI suffered traumatic facial injuries from shrapnel

Many of the soldiers lucky enough to survive WWI still returned home with horrific facial injuries left by shrapnel that had torn through their skin. Their gruesome wounds often meant they were too embarrassed to be seen in public, but sadly little consideration was given to their emotional trauma.

While stationed in France with the Royal Army Medical Corps, young surgeon Harold Gillies witnessed many of these injuries first-hand and decided something needed to be done. He persuaded the Army to set up a dedicated plastic surgery unit at the Cambridge Hospital in Aldershot where he could treat wounded soldiers returning from war. After the Battle of the Somme the unit quickly became overwhelmed with patients, and so Gillies designed and built a new hospital in Sidcup, Kent. Queen Mary's Hospital treated over 5,000 patients between 1917 and 1925, enabling Gillies to continue to develop his groundbreaking reconstructive techniques.

His work involved using grafted flaps of skin and transplanted rib bones to reconstruct facial features. For one of his early patients, Lieutenant William Spreckley, he implanted a section of rib cartilage into the man's forehead, left it there for six months to develop its own blood supply, then swung it down to build him a new nose. However, as Gillies' surgeries became more ambitious, he began to run into problems. When trying to repair the facial burns of pilot Henry Lumley, Gillies attempted to remove a massive flap of skin from his chest and transfer it to his face. However, after detaching the skin, it soon became infected and Lumley died of heart failure from the trauma of the surgery.

To overcome the issue of infected skin grafts, Gillies began using an innovative new technique called the tube pedicle. The idea was first described by a Russian surgeon, but Gillies was the first to use it as a new method of moving living tissue from one area of the body to another with minimal risk of infection.

Gillies' work during WWI earned him an OBE, a CBE and then a knighthood in 1930, and he continued using his skills in plastic surgery to treat civilian patients. When WWII broke out he helped to open several new plastic surgery units across the country and trained new surgeons to perform his techniques.

After the war Sir Gillies continued to develop pioneering new medical procedures, performing the UK's first female-to-male and male-to-female gender reassignment surgeries in the 1940s and 50s. He also founded the British Association of Plastic Surgeons and to this day is considered by many to be the father of the field, having transformed the faces, and lives, of thousands of people throughout his career.

THE BIG IDEA

The tube pedicle

Gillies knew that when moving tissue from one part of the body to another it had to remain attached to the body to maintain its blood supply. However, in a time before antibiotics, leaving the flesh exposed meant it was prone to potentially fatal infections. To solve the problem he wrapped the living tissue and blood supply within an outer layer of dead skin that would protect it from infection. This 'tube pedicle' could be left in place until a blood supply had grown into it from the new end, then the original connection could be cut and the flesh could be moved into place.

Gillies' patient Walter Yeo is thought to have been the first person treated with a tube pedicle

5 THINGS TO KNOW ABOUT... SIR HAROLD GILLIES

1 He was multi-talented
Despite suffering from a stiff elbow sustained as a child when sliding down some bannisters, Gillies was a keen rower, played golf for England, learned to play the violin and enjoyed painting.

2 He won the Boat Race
While studying at Cambridge University's Gonville and Caius College, Gillies joined the rowing club and competed in the 1904 Boat Race in which Cambridge beat rivals Oxford by six lengths.

3 He was often late
Gillies was notoriously unpunctual. Once while playing golf he forgot he was meant to have a consultation with opera singer Dame Nellie Melba and missed the appointment.

4 He loved playing practical jokes
Gillies sometimes offended people with his pranks. He liked to replace golf balls with ones of a different colour and once fooled his butler by appearing at his own front door in disguise.

5 He broke the law
The first male-to-female gender reassignment surgery that Gillies performed had to be done in secret. At the time, castration without a medical indication was illegal in the UK.

1920
He publishes his first book, *Plastic Surgery of the Face*, which contains details of his innovative surgical techniques.

1930
After receiving an OBE and CBE after the war, Gillies is knighted in King George V's Birthday Honours.

1938
Gillies is made advisor to the Ministry of Health and sets up a plastic surgery unit at Park Prewett Hospital in Basingstoke.

1946
As well as founding the British Association of Plastic Surgeons, Gillies performs the first gender reassignment surgery in the UK.

1957
He publishes his second book, *Principles and Art of Plastic Surgery*, which is part textbook, part biography.

1960
Sir Harold Gillies dies on 10 September at The London Clinic, aged 78.

BRAIN DUMP

Because enquiring minds need to know...

The Beast from the East caused temperatures as low as -30°C in Europe

MEET THE EXPERTS

Who's answering your questions this month?

JODIE TYLEY

TOM LEAN

LAURA MEARS

JAMES HORTON

JO STASS

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What caused the Beast from the East storms across Europe?

Keith Knight

■ The Beast from the East was caused by sudden stratospheric warming. During the winter months, cold air circles above the Arctic in the stratosphere, but in February 2018 that air began to slow down. This caused it to rush inwards and sink through the atmosphere, where it became warmer and started circling in the opposite direction. This reversed our jet stream, drawing in cold easterly winds instead of mild westerly winds, resulting in snowy weather. **JS**

Is the Moon getting closer to Earth?

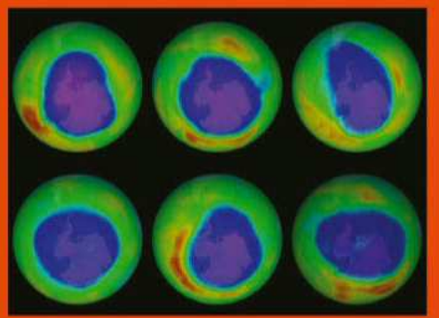
Harry Reeves

■ **No, it's actually moving further away! Simulations have shown that the Moon used to be much closer, but the Earth's tidal bulge is continuing to push the Moon outward by 3.78 centimetres every year. JH**

Is there still a hole in the ozone layer?

Mike Coles

■ In the 1970s and 80s scientists discovered that the protective layer of ozone gas in Earth's atmosphere was becoming depleted. There wasn't an actual 'hole', but ozone levels had reduced alarmingly in some regions. Banning chemicals causing ozone depletion has allowed the ozone layer to begin repairing itself in some places, like Antarctica, but ozone is still thinning in other regions and the causes are not yet understood. **TL**



Light waves travel around 880,000-times faster than sound waves

Why does sound travel slower than light?

Hannah Gould

Sound waves are merely perturbations of a medium. When molecules (in air, for example) are disturbed by an object, such as a door slamming, they are moved and knock into the molecules near them. The result is a wave of energy moving through the medium. A light wave, however, is composed of a fundamental particle, the photon. The speed of sound waves are restricted by the medium, but photons don't require a medium and have no mass to slow them down. **JH**

The first patent for waterproof fabric was granted to Charles Macintosh in 1823

How are materials made waterproof and windproof?

Louise Peacock

Weatherproof garments are made by sandwiching together different layers of materials. The outer layer is normally a tightly woven fabric, such as nylon or polyester, combined with a membrane. A membrane is a barrier that allows certain things to pass through but not others. In a waterproof jacket this layer is covered in tiny holes called pores that are small enough to prevent water droplets getting through but large enough for sweat vapour to escape. For clothing to be fully waterproof the seams must be sealed with heat-activated tape. A different kind of membrane is used for windproofing. Like the waterproof membrane, this is often made from breathable polymers (a type of plastic) full of micro pores that allow perspiration to pass through but not the elements. **JT**

Did they ever find flight MH370?

Zach Farmer

Some pieces of debris from the missing Flight MH370 have washed ashore in Africa and onto Indian Ocean islands, but investigators are still searching for the main body of wreckage. **TL**

What exactly is the difference between hardware and software?

Peter Brandt

Hardware refers to physical computing devices like laptops or hard discs. Software describes the non-physical parts of computing, such as data and programs. **TL**

Does muscle really weigh more than fat?

Xiao Hsing

Technically, no, but it is denser than fat. Someone muscular might weigh the same as someone with more fat, but they will appear to be smaller because the muscle takes up less space. **LM**

What is homeopathy?

Julieta Alves

Homeopathy is a type of alternative medicine based on two main principles: that substances that cause symptoms can treat the same symptoms, and that diluting a substance in water makes it more powerful. There is no evidence that it works. **LM**

BRAIN DUMP

What is misophonia?

Brianna Hannam

■ Although literally defined as the 'hatred of sound', sufferers of misophonia don't despise all forms of noise. Rather, sufferers of the condition are sensitive to hearing certain 'triggers' that elicit immediate and strong negative emotional responses. These vary from person to person, but common trigger sounds include chewing, nasal breathing and scraping silverware. **JH**

More common in girls, misophonia tends to develop during childhood

Why don't plastic items dry in the dishwasher?

Kathy Hall

■ When you run your dishwasher, the items inside get very hot. At the end of the cycle this heat dries the dishes by causing water to warm up and evaporate. This works really well with china and glass because these materials store a lot of heat and are good conductors, meaning the heat energy inside is transferred easily to the surface to evaporate the water. Plastic dishes, however, are poor heat conductors and are made of lighter and thinner materials that can't store as much heat, so water on their surfaces doesn't get hot enough to evaporate effectively. **TL**

Mucus and oil build up in the corners of our eyes as we sleep

What is 'sleep' that forms in the corner of your eyes?

Felicia Wallace

■ It's called rheum, and it's a combination of watery mucus and oily meibum. During the day it helps to keep the eyes moist and clean, preventing them from drying out and trapping any debris on the surface. It's usually washed away by blinking, but at night it can start to build up. It collects in the corners of the eyes and in the eyelashes, where it dries to form that familiar yellow-coloured sleep dust. **LM**

What are foam rollers?

Caterina Boni

These long foam cylinders are used for deep-tissue massage. By slowly rolling over parts of the body, they are believed to enhance flexibility and aid muscle recovery after exercise. However, research is still being carried out in this area. **JT**

How does hairspray work?

Ali Gill

The sticky secret is polymers – chain-like molecules that form bonds and fix hair in place. Hairspray contains liquid to prevent them solidifying. Once sprayed, the drops form a film that bonds hairs together. **JT**

Who invented the doorbell?

Ryan Brookes

Scottish engineer William Murdoch created a mechanical doorbell operated by pipes of compressed air in 1817. In 1831, American scientist Joseph Henry invented the first electric doorbell operated from a distance via electric wires. **JS**

Is it possible to train a cat?

Kelly Harrison

Cats can be trained but only through positive reinforcement, not punishment. Rewarding a cat with attention or food when they do something good (ie use their cat flap) will cause them to associate that behaviour with a positive outcome, so they will be more likely to want to do it again. **JS**

Custom masks keep people still when they receive radiotherapy treatment

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How does proton beam therapy work?

Christa Dasselaar

Proton beam therapy is a type of radiotherapy used to treat certain cancers. Like other radiotherapy treatments, it works by damaging cancer cells with high-energy radiation. In standard radiotherapy a machine shapes beams of X-rays to fit the outline of the tumour. The X-rays pass through the body and collide with the cancer cells, but then they keep going, damaging the surrounding tissue. Proton beam therapy uses protons instead of X-rays, and these stop when they hit their target. This helps to reduce side-effects when treating complex cancers that sit close to vital tissues, like tumours in the brain or the spinal cord. **LM**

Why do pipes 'knock'?

Elizabeth White

This engineering phenomenon, commonly known as a 'water hammer', is a loud banging sound that can occur when a tap or valve is turned off quickly. The water that was flowing through the pipe has nowhere to go, and this causes a build-up of pressure. However, a water hammer isn't just noisy; it can lead to burst pipes. To reduce the pressure, air chambers are fitted near valves to absorb the impact. **JT**

Medical terms for goosebumps include piloerection and horripilation

Why do we get goosebumps?

Chris Glover

Goosebumps are a physiological response left over from our hairy ancestors. When we are cold or stressed our brain releases a hormone called adrenaline that causes muscles attached to each hair on our skin to contract. This creates a shallow depression on the skin's surface, making the surrounding area stick out. While this provided our ancestors with a thicker layer of insulation and a look that frightened off attackers, today it doesn't serve any purpose as we are a lot less hairy. JS

Why was the European Union formed?

Andy Carr

The first half of the 20th century was marred by two World Wars, the likes of which humanity had never seen before. Europe had found itself at the epicentre of both wars, and after the second had come to a close, the countries of the continent were resolute that they would never wage war against one another again. It was from this noble goal of peace that the European Union was formed. In 1950, the founding states tied together their production of coal and steel – both integral ingredients for a war campaign. Free trade between member states soon followed, encouraging cooperation and inspiring more countries to join. **JH**

The concept of the European Union was the idea of 11 political leaders, including Winston Churchill

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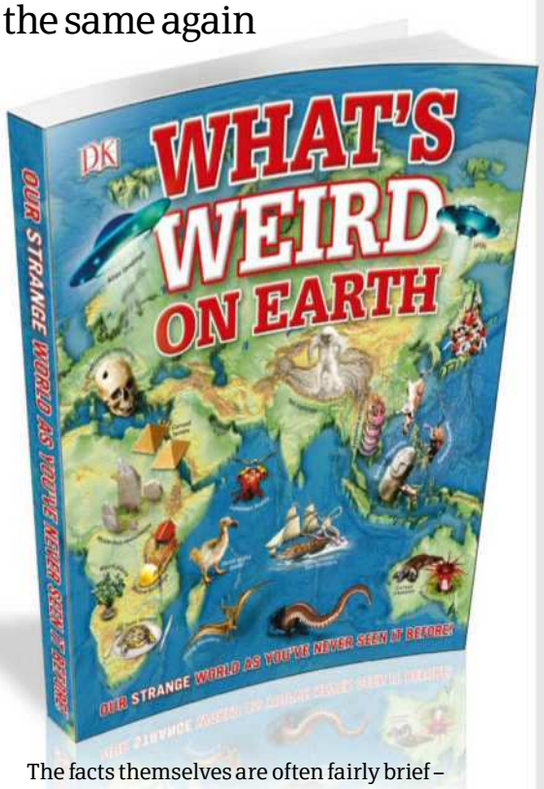
BOOK REVIEWS

The latest releases for curious minds

What's Weird on Earth

Planet Earth will never seem the same again

- Author: **Various**
- Publisher: **DK**
- Price: **£14.99 / $19.99**
- Release date: **Out now**



Atlases are interesting, but they all too often provide standard information without much in the way of excitement. Thankfully, DK is changing this with its new series of books. We were big fans of *What's Where On Earth* when we reviewed it a few months ago as it offered a unique look at the world and its most famous landmarks, geographical highlights and weather. Now with *What's Weird On Earth* we get a slightly more bizarre glimpse at the world around us.

At its core this book is an atlas, and across its 160 pages you'll find dozens of maps of the six major continents. But don't worry – the pages certainly don't all look the same. Each double-page has been carefully designed, with a clever use of colour, imagery and other visual tricks helping every spread feel unique.

The information contained within them is equally varied. On one page you'll be learning about a rain of spiders that fell in Australia and blanketed the area in webs. On the next you'll hear how 28,800 rubber ducks that went overboard from a ship into the Pacific Ocean in 1992 are now helping oceanographers track and time the ocean currents. You'll also find out about the no-go zones that most humans can't access (like the vault holding the secret Coca Cola recipe in Georgia, US) and the mysterious artefacts found around the globe that still have scientists puzzled.

Each of these facts is backed up by well-designed graphics or photography to give readers a better idea of what they're looking at. The facts themselves are often fairly brief – usually just a sentence or two – but they're all interesting enough that you'll be reading them aloud to other people in disbelief. We certainly did. Because they're so short you're encouraged to go away and do some more research of your own to find out more about your favourites. It's great that there are so many facts packed into this large book, but we would've loved to have had some extra detail in there as well.

Still, if you know any young minds looking for stimulation (or older minds that just want to learn some incredible facts) then this is a fantastic choice. DK deserves praise for helping to bring the atlas into the 21st century.

★★★★☆

The 50 Greatest National Parks of the World

Where to visit next?

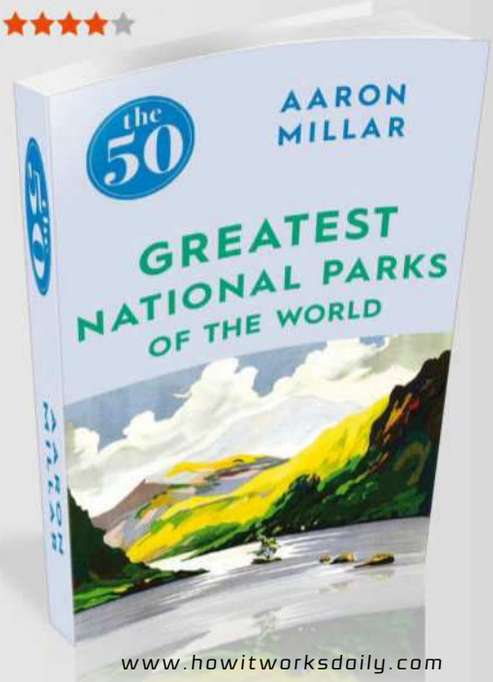
- Author: **Aaron Millar**
- Publisher: **Icon Books**
- Price: **£8.99 / $14.95**
- Release date: **Out now**

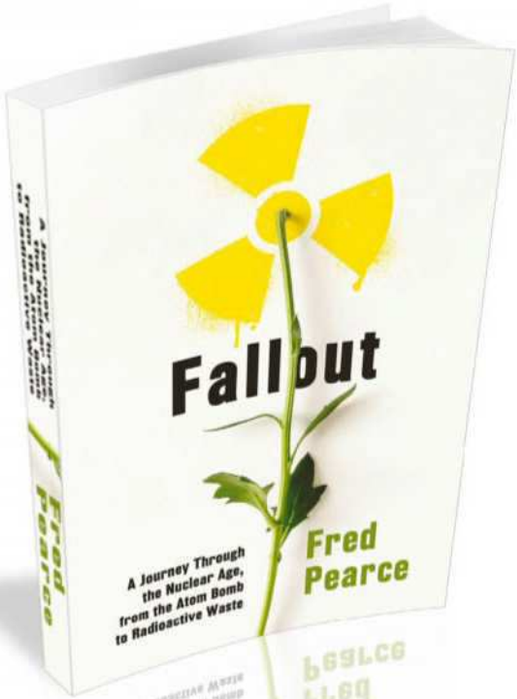
There's something about the title of 'national park' that confers on a place a certain kind of aura; that it is somewhere to be treasured, a haven of beauty and national identity. Travel writer Aaron Millar has had the pleasure of visiting many such locales, and he narrows the list down to 50 in this book.

It's probably not unfair to say that most readers won't have previously heard of many of the destinations that are mentioned here (only three UK parks make the list), making this a potential repository of new discoveries. And it's new experiences that Millar focuses on, detailing the history of the park before following on with a top tip and some advice on the best things to do.

Inevitably, this book isn't especially comprehensive, with most parks only getting around four or five pages devoted to them. Rather, this book is more likely to point you in the direction of potential future destinations as opposed to making an outright case for you to go there.

★★★★☆





Fallout: A Journey Through the Nuclear Age, from the Atom Bomb to Radioactive Waste

Peering through the mushroom cloud

- Author: **Fred Pearce**
- Publisher: **Portobello Books**
- Price: **£14.99 (approx. $20)**
- Release date: **Out now**

Nuclear energy doesn't have the best reputation, its very mention more synonymous with destruction and disaster than as a means of fuelling humanity. Hiroshima, Chernobyl, Fukushima et al stand as testament to this, and the three-pronged symbol that denotes 'nuclear' might as well have become a skull and crossbones for the image that it conjures now.

With the brief of separating facts from fear, journalist and author Fred Pearce looks to find causes for optimism in places you wouldn't generally expect to find any, namely old test sites, abandoned power stations and former no-go zones. What he finds may well surprise you, even if it probably won't completely allay your fears about such a potentially volatile energy source.

While its aim hasn't necessarily been achieved, such is the enrapturing nature of Pearce's writing style and his Bill Bryson-esque ability to seamlessly interweave facts, trivia and history into his narrative that you probably won't mind all that much. A radiating read.

★★★★☆

> "The nuclear symbol might as well have become a skull and crossbones"

Mason Jar Science: 40 Slimy, Squishy Super-Cool Experiments

Science with street cred

- Author: **Jonathan Adolph**
- Publisher: **Storey Publishing**
- Price: **£11.99 / $14.95**
- Release date: **Out now**

With the summer holidays fast approaching, you might already be wondering about ways to keep your young Einsteins amused. Fortunately, this book might well have the answer, providing you with no less than 40 projects that are possible to construct from the comfort of your own home.

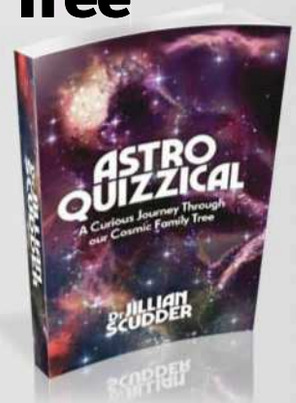
Most of these are aimed at demonstrating various scientific principles (like bending light and magnetism), while others simply show how to create cool things, such as grass jars, rain gauges and a tiny tornado in a jar (this is nearly worth the price of the book alone). If it seems improbable or downright odd then it's probably included in these pages.

Some of the experiments are a bit complex, so parental supervision will likely be required, especially when obtaining the various components. Still, it's all worth it in the quest to engage young minds and keep them occupied in the process.

★★★★☆

Astroquizzical: A Curious Journey Through our Cosmic Family Tree

The Solar System's history revealed



- Author: **Jillian Scudder**
- Publisher: **Icon Books**
- Price: **£16.99 / $24.95**
- Release date: **Out now**

We've read a lot of books detailing Earth's early years but not many on the growth of the rest of the Solar System and our place within it. Astrophysicist Jillian Scudder seeks to redress the balance in *Astroquizzical*, going where surprisingly few have gone before.

It's a lofty subject matter indeed, but Scudder doesn't seem daunted; on the contrary, the opportunity to confront such topics as space wormholes and interplanetary travel is seized upon with relish, the big questions succinctly broken down into bite-sized chunks. Also of note are the regular 'thought exercise' features interspersed throughout, adding interactivity to a medium that it's not always the best fit for.

Books about the cosmos tend to be so at pains to stress how much we *don't* know that it's easy to question whether we know anything. This book will restore your optimism.

★★★★★

BRAIN GYM

GIVE YOUR BRAIN A PUZZLE WORKOUT

Wordsearch

J	W	L	A	R	A	B	Y	P	A	C	M	B	P	Q
B	O	L	A	I	B	O	A	C	U	W	O	A	Y	H
E	R	A	P	T	E	I	V	N	J	N	N	F	D	R
C	L	F	T	R	O	P	R	I	A	C	O	X	G	H
I	D	R	G	E	Q	G	X	C	R	S	V	U	S	O
Y	C	E	N	R	N	H	L	E	P	Y	S	E	A	L
R	U	T	U	L	D	O	A	D	S	E	Z	I	S	L
D	P	A	O	X	V	S	T	Y	Q	N	S	H	N	Y
G	I	W	T	R	B	A	R	S	H	K	L	W	O	W
J	Y	O	E	A	N	U	I	C	W	C	N	P	I	O
E	V	P	R	Z	S	N	A	G	R	O	Y	J	T	O
C	U	S	U	E	K	R	F	S	G	C	L	R	O	D
S	F	H	O	Q	T	X	M	O	T	Z	D	L	M	P
J	P	W	A	D	T	S	F	B	V	A	R	G	E	G
L	A	C	I	R	E	M	A	V	N	U	V	B	C	Y

FIND THE FOLLOWING WORDS...

AIBO
AIRPORT
AMERICA
ASTEROID
CAPYBARA
COCKNEY
DRYICE
EMOTIONS
HOLLYWOOD
NHS
NISSAN
ORGANS
PANCREAS
SUPERVOLCANO
TAN
VAR
WATERFALL
WORLDCUP
YELLOWSTONE

Quickfire questions

Q1 What is the most abundant element in the human body?

- Hydrogen
- Helium
- Carbon
- Oxygen

Q2 Earth's axis is tilted by ____

- 25.3°
- 32.5°
- 23.5°
- 52.3°

Q3 The planet Jupiter was named after ____

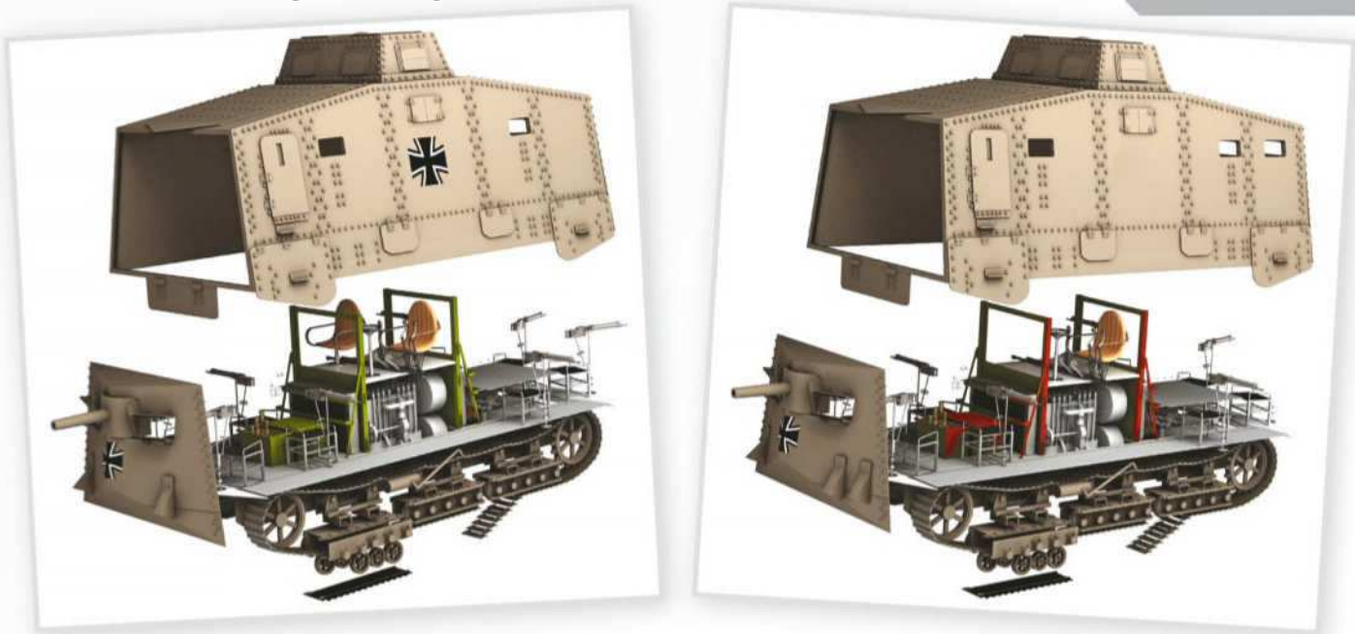
- Roman god of war
- Greek god of the sea
- Greek king of the gods
- Roman king of the gods

Q4 What does FIFA stand for?

- Football Industry Fantasy Association
- Fédération Internationale de Football Association
- Fédération Increíble de Football Association
- Football International Federation Aggregate

Spot the difference

See if you can find all six changes we've made to the image on the right



Sudoku

Complete the grid so that each row, column and 3x3 box contains the numbers 1 to 9.

EASY

5		6	1	9		3		7
8		4		7	2			
				8		9		2
2		8	4	6			3	
		5		3	7			1
		9	8	2		6	5	4
3	6			5	9	4	7	8
			6	1		2	9	5
	5			4	8	1		3

DIFFICULT

				2				
	6			7			8	
1			8				4	
3		9				7		2
						3		8
5			6		3		9	
	2	4			8			
		1	5				3	
8			4		9			

What is it?

A .....

▶ Visit our website at **www.howitworksdaily.com** to check your answers!

Get in touch

Want to see your ideas on this page? Send them to...

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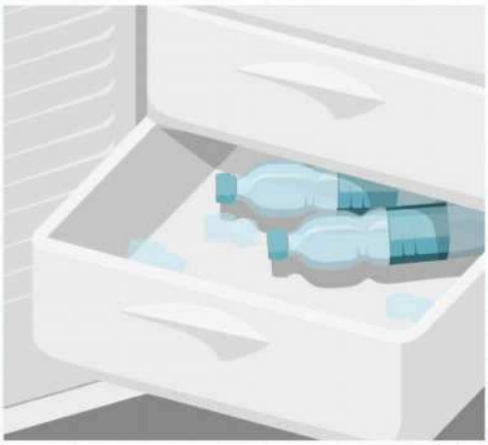
howitworks@futurenet.com

DON'T DO IT ALONE
IF YOU'RE UNDER 18, MAKE SURE YOU HAVE AN ADULT WITH YOU

Freeze a glass of water instantly

Get the power of a superhero and freeze a glass of water with a single touch!



1 Cool your water

First you need to freeze some purified water. You might think that you can make your own purified water for this experiment by boiling it for a few minutes, but that won't remove the chemicals in the water, so you'll need to buy specially purified water instead. Take three unopened 500ml plastic bottles of the water and place two of them in the freezer on their side.

2 Be careful!

After 30 minutes put in a third bottle. Having more than one bottle will increase your chances of this working, so you can put in even more if you want to try this a few times! You need to leave your water in the freezer for two hours and 15 minutes in total. Make sure to leave the water as undisturbed as possible while it's in your freezer, as agitation can start the crystallisation process.

3 Carefully remove it

After two hours and 15 minutes, slowly open the freezer and very carefully remove the lid of the bottle. If the process has worked correctly the water should still be liquid, but it will have been supercooled to below its freezing point. Tilt the glass you're going to use and slowly pour the water into the glass. If you're careful, the supercooled liquid shouldn't start to solidify.

4 Grab some ice

You'll need some crushed ice for this part. Put your finger into the crushed ice and make sure that there's at least one ice crystal stuck to your fingertip. That's all it will take to start the crystallisation process in the rest of the water. When you've got a crystal on your finger, gently lower your finger into the glass of supercooled water and watch what happens.

5 How did that happen?

If everything has worked properly the water should instantly start to solidify, with ice crystals spreading through the water to make ice. If you want to skip this step you can always just leave the water inside its plastic bottle and hit it on the side to kick-start the process. That one small movement is all that's needed to start a chain reaction through all the molecules in the water!

"The water should start to solidify, with ice crystals spreading through the water"

In summary...

Tap water will usually freeze at 0°C because of the chemicals and impurities in the water. The molecules can latch onto these impurities, and freezing is simple. In purified water there are no impurities, so if you're careful the water can be cooled to well below its normal freezing point.

Make magnetic slime

Create a weird goop that will be attracted to magnets!

NEXT ISSUE
EXPERIMENT WITH STATIC ELECTRICITY
MAKE A TISSUE BOX CATAPULT

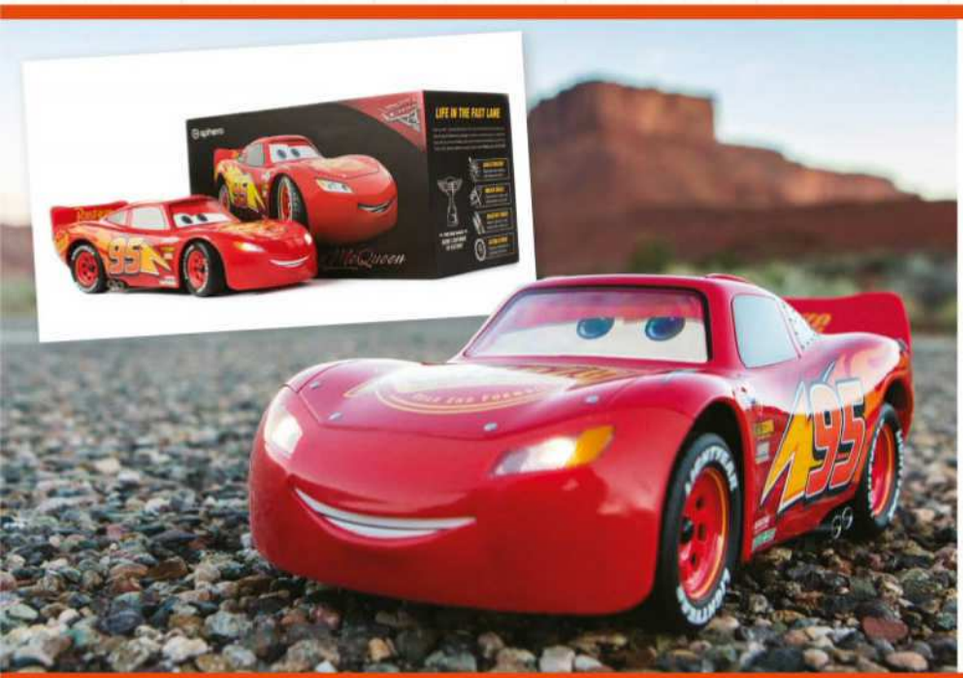
1 Create your slime
First pour 60ml of liquid starch into a disposable paper bowl. Being careful not to get too much dust in the air, add two tablespoons of iron powder to the bowl and mix. If you're worried about the dust you might want to wear a mask. Alternatively, you can use iron filings. Add in 60ml of PVA glue and start mixing.

2 Get your gloves dirty
Your goo won't look very good at first as the white streaks of glue will take a long time to mix into the rest of the liquid. Keep mixing (we recommend using a lolly stick for this), then put on some disposable gloves and start mixing it with your hands. Keep squashing it together until it's all mixed nicely.

3 Magnetise!
Pat your slime dry with a paper towel to get rid of any excess liquid. It's this liquid that will stain your hands, so once it's 'dry' you can take your gloves off. Now put down a sheet of greaseproof paper, then find a strong magnet (ideally a neodymium one). Bring it close to your slime and it will start to ooze towards it.

"Your slime will start to ooze in the direction of the magnet"

In summary...
The iron powder in the slime is drawn into the strong magnetic field of the magnet, but as it's in thick slime, moving towards the magnet is more difficult. Because it's mixed so well with the slime you should see tendrils of goo being dragged towards the magnet when it's nearby!



WIN!

An interactive Ultimate Lightning McQueen worth £299.99!

Fans of the *Cars* franchise will love the Ultimate Lightning McQueen racer from Sphero and Disney Pixar. Packed full of advanced technology, this top-of-the-line car's animatronics bring Lightning to life like never before. Connect with Lightning via the accompanying app and you can take the wheel.

What is the name of the Yellowstone Park geyser that erupts at regular intervals?

a) **Old Faithful** b) **Old Yeller** c) **Old Geezer**

▶ Enter online at **www.howitworksdaily.com** and one lucky reader will win!

INBOX
Speak your mind...

Get in touch
If you have any questions or comments for us, send them to...

How It Works magazine @HowItWorksmag howitworks@futurenet.com

The fire burnt slowly for several days because a lack of oxygen deep in the wood meant it could only partially combust

Letter of the Month

Mysterious burning log

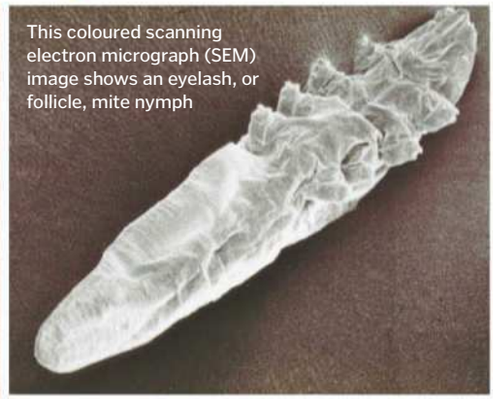
Dear **HIW**,

We had a fire last night and we have come back this morning and the wood is still burning. It's also getting hotter as we are watching it. We have attached a video to this message and would like to have help explaining why this happened.

Many thanks,

Emma and Andre

We think the answer lies in the lack of oxygen in the chunk of wood you were burning. Fire is the result of burning fuel in the presence of oxygen. In this case the fuel is the chunk of wood. When the fuel is completely combusting you will see flames, but during partial combustion you get embers instead. It looks like the piece of wood isn't fully combusting, only partially. It's the same process that is happening when you see the hot embers after you've had a fire and let it die out – the embers are usually still glowing but they're coated in white ash. But in this partial combustion state, there is still unused — but usable — chemical energy deep inside the wood and the coals of the original fire, where oxygen cannot reach it. Without a good supply of oxygen, the wood can only stay in this partial combustion state. It would need lots more oxygen to burst into flames properly, but even when it's partially combusting it stays hot and doesn't lose much thermal energy. It could possibly have burnt like this for days. The combustion is happening at a low level but there just isn't enough to create a flame. This phenomenon can be really dangerous when it happens in a forest fire. A small piece of debris can be blown over a great distance without being extinguished, and it will fully ignite once it has landed somewhere else. This means a forest fire can spread rapidly and cross rivers and lakes. We hope we've answered your question, and thank you very much for writing to us.



This coloured scanning electron micrograph (SEM) image shows an eyelash, or follicle, mite nymph

Creepy crawlies

Dear **HIW**,

Is it true that there are creatures living in our eyebrows?

Thank you,

Oscar Schultz, age 12

It's not a pleasant thought that there are tiny creatures living in our eyebrows, but it is in fact true: they are mites known scientifically as Demodex. They are not too fussy when it comes to finding a place to live, and they will set up home in almost any hair follicle on your body. You can't see them because they only grow to between 0.3–0.4 millimetres long and have almost completely transparent bodies consisting of two segments with eight stubby legs. Demodex use a pin-like mouth to feast on your skin cells and the oil on your face. Don't worry though, they're usually harmless (but still gross).

Venus flytraps

Dear **HIW**,

I was wondering how my Venus flytrap knows when a fly lands on it? It always snaps shut when something lands there, but I don't know why.

Alex

Venus flytraps are amazing because they're able to digest insects. If you look really closely, you will see tiny hairs on the inside of the leaves. These are known as 'sensitive hairs'. They're not very intimidating to us, but to a fly they're a real killer. Once an insect lands on them, they trigger the plant to snap shut.

Satellites in orbit

■ Dear **HIW**,
We have a question about satellites because we saw one through our telescope. How do they stay in orbit and not crash into the ground?
Thank you,
Sophie and James

Satellites are able to stay in orbit because their momentum balances the pull of Earth's gravity. With too much momentum, a satellite would escape Earth's gravity and continue drifting in a straight line out into space. Too little, and it would eventually fall back to Earth. Scientists have to carefully calculate these launches depending on the intended orbit, to make sure they deploy satellites with enough momentum.

A pondering on parakeets

■ Dear **HIW**,
We have lineolated parakeets and were wondering why they make such strange noises. You know old-school cameras used to click and whir – they seem to be making that noise. Thanks!
Beth

We're not sure why your parakeets are making that exact noise, but their natural call is a soft, song-like sound. They use an organ unique to birds to make their sounds called a syrinx. That said, lineolated parakeets are also able to mimic sounds (including words), so they might be repeating a sound they have heard in your home. Thanks for writing to us, we hope that offers some insight.

Birds don't have vocal cords but they can make sounds using their throat muscles and membranes

What's happening on... social media?

This month we asked you: If you could have any animal as a robotic pet, what would you pick and why?

"For me I would love a #robotic rabbit... then I could let it out in the garden to run around and be safe"
@zenakate1

"Definitely a robotic rhino because why not? And also because I can ride it, and nobody would dare to stop me"
@RoseMEWW

"A robotic owl to deliver my post Harry Potter style!"
@ClareJFox

"A giraffe - to have a great view"
@KarenHutchy73

"A robotic dog wouldn't have to be walked but would still be girl's best friend"
@serenacooper4

Highlights from the Twitterverse

"Not every day I can hang with a great astronaut and a great guy!!! Tim Peake!!! Hurrah!"
@DrBrianMay

"A mind-blowing fact...mosquitoes will kill more people today than sharks do in a century"
@BillGates

"By the way, one of the conclusions echos Feynman's 'The Value of Science' - we make mistakes because we don't know everything, but the strength of democracy is that it never gets stuck with a bad idea for long. In this respect, democracy is very similar to science."
@ProfBrianCox

"How many worlds exist outside our solar system? @NASA_TESS launched from planet Earth today at 6:51pm ET to hunt for planets around some of the closest & brightest stars. TESS will use 4 cameras to search nearly the entire sky for unknown worlds."
@NASA

HOW IT WORKS

Future PLC Richmond House, 33 Richmond Hill, Bournemouth, Dorset, BH2 6EZ

Editorial
Editor **Jackie Snowden**
Senior Art Editor **Duncan Crook**
Research Editor **Baljeet Panesar**
Production Editor **Charlie Ginger**
Staff Writer **Charlotte Evans**
Staff Writer **Scott Dutfield**
Group Editor in Chief **James Hoare**
Photographer **James Sheppard**

Contributors
Adrian Mann, Alex Phoenix, Ed Crooks, James Horton, Jamie Frier, Joanna Stass, Jodie Tyley, Jonathan O'Callaghan, Laura Mears, Lee Cavendish, Nicholas Forder, Stephen Ashby, Steve Wright, The Art Agency, Tim Williamson, Tom Lean, Victoria Williams

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Advertising
Media packs are available on request
Commercial Director **Clare Dove**
clare.dove@futurenet.com
Group Advertising Director **Mark Wright**
mark.wright@futurenet.com
Advertising Manager **Toni Cole**
toni.cole@futurenet.com
01225 687368
Media Sales Executive **Jagdeep Maan**
jagdeep.maan@futurenet.com
01225 687353

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Head of Art & Design **Greg Whittaker**

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FAST FACTS

Amazing trivia to blow your mind

ON A HOT DAY, THE SEATTLE SPACE NEEDLE EXPANDS BY ABOUT 2.5CM

IN ENGLAND ALONE, THE NHS DEALS WITH OVER

1 MILLION

PATIENTS EVERY 36 HOURS

YELLOWSTONE'S SUPERVOLCANO LAST ERUPTED

640,000

YEARS AGO

41,820

THE NUMBER OF AIRPORTS OR AIRFIELDS IN THE WORLD ACCORDING TO THE CIA

NASA CURRENTLY TRACKS OVER

450

NEAR-EARTH OBJECTS THAT COULD PASS WITHIN THE MOON'S ORBIT

THE DENMARK STRAIT CATARACT IS OVER

3.5x

TALLER THAN ANGEL FALLS IN VENEZUELA

ONE STUDY FOUND THAT WEARING A MOTORCYCLE HELMET REDUCES THE ODDS OF DEATH IN A CRASH BY 42%

6,000

THE NUMBER OF PEOPLE IN THE UK WAITING FOR AN ORGAN TRANSPLANT AS OF APRIL 2018

130,000+

MALIGNANT MELANOMAS OCCUR WORLDWIDE EACH YEAR

BETWEEN 1870–1900 THE US WELCOMED NEARLY

12 MILLION

IMMIGRANTS

THE KÁRMÁN LINE, 100KM ABOVE SEA LEVEL, IS USED TO DEFINE THE BOUNDARY BETWEEN EARTH'S ATMOSPHERE AND SPACE

4.7M x 2.8M

THE SIZE OF THE WORLD'S LARGEST SHIP IN A BOTTLE

GLOBALLY, THE NUMBER OF PEOPLE WITH DIABETES IS ESTIMATED TO BE

415 MILLION

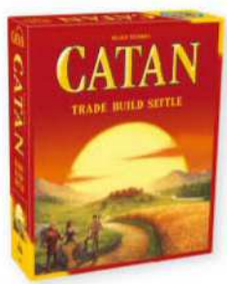
MODERN Classics

Splendor

Travel back to the Renaissance and become a wealthy jewel merchant in Splendor, a card game of clever plans and glittering gemstones for two to four players.

Enter a world of prestige and jewels with this easy to learn and challenging strategy game, rich in historical detail!

PART OF THE MODERN CLASSICS RANGE



AIRFIX

QUICK BUILD

J6000 Spitfire

1	9.12 m	11.23 m
22.48 m²	2,182 kg	571 km/h
925 B km A	771 m/m	9,723 m

1 x Rolls Royce Merlin II V12

- Includes 34 plastic parts
- Includes rotatable propellers so your Spitfire can soar high with pride
- Features a self-adhesive sticker sheet for authentic decoration
- Includes a stand to show off your handywork
- Model has smooth lines just like the real thing
- Compatible with other plastic brick brands!

A Model Aircraft

THE SUPER SUPERMARINE SPITFIRE

On 5th March 1936, Eastleigh Aerodrome near Southampton hosted one of the most important events in the history of British aviation. As chief test pilot Joseph 'Mutt' Summers strapped himself into the cockpit of the Supermarine Type 300 interceptor prototype K5054, he knew that he would be flying one of the most advanced aircraft the world had ever seen. During a brief eight minute flight, the aircraft showed so much promise, that on landing, Summers told the engineers waiting on the ground 'Don't touch a thing!'

The Supermarine Type 300 was soon given the name 'Spitfire' and an aviation legend began to take shape. Arguably the most famous fighter aircraft of all time, the Spitfire proved itself during the savage dogfights of the Battle of Britain and went on to serve valiantly in every conflict during the Second World War. The Spitfire was produced in more numbers than any other British combat aircraft. Throughout its sixteen year service life the airframe proved to be so adaptable that the aircraft was significantly improved with the last Spitfires producing more than double the power of the first machines!

The graceful, sweeping lines of the distinctive Supermarine Spitfire sometimes make it difficult to imagine that this was actually one of the most deadly fighter aircraft the world has ever seen. The Spitfire is still as iconic as a part of Britain's history today, as she was ground breaking when she first took to the skies 82 years ago.

The Spitfire really is a British icon and you can recreate your very own at home with an Airfix QuickBuild kit. QuickBuild kits give you the ability to recreate a wide variety of iconic aircraft, tanks and cars into brilliant scale models. No paint or glue is required, the push together brick system results in a realistic, scale model that is compatible with other plastic brick brands.

Collect them all! Check out the rest of the range online.

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J6024 Camper Van

J6020 Bugatti Veyron 16.4

Airfix.com and all good retail stockists YouTube

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